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A New Era in Loading

By WILLIAM FONDILLER
Assistant Apparatus Development Engineer

IN 1900 were issued the basic Pupin patents on the loading of telephone lines. Up to the present time savings of approximately $200,000,000 in plant investment have resulted from the use of loading coils in the local-cable plant. An additional saving of fully half this amount has been realized in the toll-cable plant, due to the combined use of loading and vacuum-tube repeaters. Thus, the development of suitable designs of loading coil to meet the severe conditions of the modern telephone network is a problem of the first importance.

The idea of "loading" in telephony is analogous to the loading of a vibrating string with equal weights uniformly spaced along its length. If the distance between weights is sufficiently small, the vibration of the loaded string will be practically the same as that of a uniformly heavy string of the same mass. In the case of the telephone line, loading is accomplished by connecting inductance coils at regular intervals in the circuit as shown in Figure 1, thus increasing the electrical mass of the line. This increased mass reduces the friction (resistance) loss and, reacting with the elasticity (capacitance) of the circuit, also reduces distortion. Thus a speech wave entering a loaded line is transmitted with less attenuation and alteration of the wave form than in the case of a non-loaded line. In terms familiar to the power engineer, the loaded line transmits at a higher line-voltage, lower line-current and higher power-factor than the non-loaded circuit. The transmission loss may readily be reduced by loading to a third of its value for the non-loaded cable circuit, so that the same transmission efficiency would be obtained in a loaded cable three times as long as the corresponding non-loaded cable.

The usual form of loading coil consists of a toroidal or ring core with a copper winding applied over it. The spacing of loading coils in cable is generally about one mile. Thus in the case of a long circuit, such as the New York-Chicago cable, the talking current would traverse

the windings of approximately 900 loading coils connected in the toll line.

In the early loading coil the core was formed of hard drawn fine iron wire—one of the rare instances of designedly using for a core an unannealed magnetic material. The explanation is that the advantage of loading inheres in the inductance which the coil adds to the talking circuit, but this inductance can be introduced only if the speech currents traverse the coil windings and hence sustain losses due to the resistance of the winding and to eddy currents and hysteresis in the core. All of these losses must be kept low by proper coil design and since those due to hysteresis and eddy currents increase rapidly with the permeability of the core, a low limit of permeability is imposed. Our loading coil designs at the outset employed cores developing only the initial permeability of the core material, approximately 35, whereas in the electrical industry generally the aim was to use the maximum permeability obtainable in iron, in the neighborhood of 5,000.

Wire-core loading coils met the requirements of the plant up to about 1914. By that time a successful design of vacuum-tube telephone repeater had been developed, but it could not be used advantageously on lines loaded with the coils then standard. The reason for this incompatibility was the unstable inductance of the coils which would undergo large changes, due to excessive currents in the telephone lines produced under abnormal conditions of operation or by induction from outside sources. Such currents seriously magnetized the core and altered its permeability.

There followed from an intensive period of development work a type of loading coil in which a stabilizing self-demagnetizing effect was secured by the introduction of non-magnetic gaps in the toroidal core. This solution was later superseded by a much more satisfactory one, involving the introduction of in-

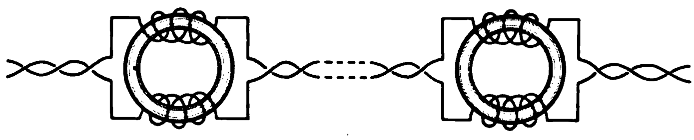


Fig. 1—Method of connecting loading coils into cable pair

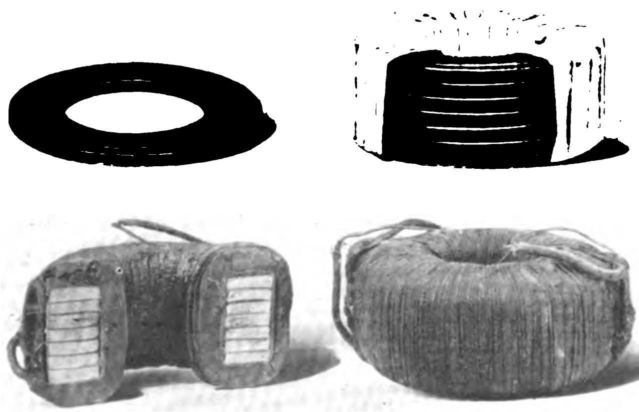


Fig. 2—Loading coil with compressed powdered core: top, left—core ring, right—partially taped core; bottom, left—coil sectioned, right—coil ready for potting

numerable minute gaps resulting from our development of a new magnetic material, compressed powdered iron.

The essential improvement in core material demanded for repeater operation was increased magnetic stability when subjected to large magnetizing currents. This was achieved to a high degree by the powdered electrolytic iron core. Where the older loading coils were liable to a permanent change in inductance of over 25%, the new coils maintained their inductance to about 2% under similar service conditions. Another important characteristic was the enormous resistivity of the finely-divided iron, resulting in lower eddy-current losses than for rolled or drawn metal. Cores were conveniently formed by stacking compressed rings of powdered iron as shown in Figure 2.

This material, first introduced on a commercial scale in 1916, was revolutionary in importance and for the past ten years has been standard for loading-coil cores. So economical were the powdered iron cores, as compared with the iron wire cores, that they rapidly superseded the latter, and the use of vacuum-tube repeaters, in association with loaded circuits, became general in the Bell plant.

Over this period extensive developments occurred in telephony and telegraphy, involving vacuum-tube repeaters, carrier-frequency transmis-



Fig. 3—Casting permalloy into ingots suitable for later crushing and grinding

sion and extensions of loaded cable. It was at this stage of the communication art that there evolved the remarkable nickel-iron alloy, permalloy, discovered by G. W. Elmen. Its striking combination of properties, the highest initial permeability and lowest hysteresis loss of any known material, arrested the attention of our design engineers who immediately began to consider its possible uses in electrical communication.



Fig. 4—Compressed powdered core loading coils: left, electrolytic iron core; right, permalloy core

Its first important application was to the continuous loading of transoceanic telegraph cable where high permeability was essential. Here the permalloy in ribbon form was spirally wound over the submarine cable conductor. Other applications were in the design of electromagnets and transformers which also employed strip or sheet permalloy cores. The problem of its use for loading coil cores did not, however, readily yield to solution.

At the outset it was evident that permalloy in the form used for submarine telegraph cables was wholly unsuited as a loading coil core material. Its susceptibility to permanent magnetization and the variation of its permeability with current rendered it markedly inferior even to iron wire as a loading coil material. However, its intrinsically low hysteresis remained a sufficient lure to those seeking a means to utilize it.

Our experience with powdered electrolytic-iron for cores pointed to a means for correcting the magnetic instability of permalloy by having recourse to a multi-airgap core. The problem then was to produce a core of powdered permalloy which should retain to as great a degree as possible the desirable properties of sheet permalloy. Through the metallurgical skill of the development engineers of the Western Electric Company, combined with the experience of our Laboratories, the problem was solved. Means were developed by which permalloy was embrittled so that it could readily be ground to the desired fineness and these operations, accompanied by suitable heat treatments, yielded the compressed powdered-permalloy core of today.

This development, described here in a few sentences, required, however, continuous experimental work over a period of several years before it was brought to a successful issue. It represents the result of highly cooperative efforts, embracing researches and developments in chemical, metallurgical and electrical fields.

Between the powdered and the sheet permalloy differences in properties exist amounting almost to an antithesis—each material being eminently suited to the use to which it is applied. Sheet permalloy has an initial permeability of approximately 7500, powdered about 75. In re-

sistivity, on the other hand, powdered permalloy is approximately 50,000 times as great as sheet permalloy. The residual effect of d.c. magnetization on sheet permalloy results in a reduction of about 50% of the initial inductance; for powdered permalloy only one-half percent.

These striking differences in characteristics are, of course, due to the fine subdivision of the permalloy in the powdered core, in the production of which each grain is carefully insulated before pressing the core rings. Though permalloy in sheet form was not itself suitable, it nevertheless constituted a strong invitation to develop a core design adapted to the loading coil problem. Not by virtue of the extremely high initial permeability which made it valuable for submarine cable, but because of its low hysteresis has it become suitable.

As compared with the powdered iron core, the new permalloy core has greater magnetic stability and approximately twice the permeability. The effect on the physical dimensions is indicated in Figure 4 which shows the No. 612 powdered-permalloy-core alongside of the No. 602 powdered-iron-core coil. In both cases the cores are formed by steel dies under pressures of 200,000 pounds per square inch. The two coils have substantially the same efficiency over the range of speech frequencies, but their relative volumes are about as 1 to 3. Figure 5 shows cases equipped with 200 coils of the types just described and indicate the marked saving in space. This is of great importance, particularly in metropolitan areas, where space in loading vaults is extremely valuable.

At present loading coils are being placed in the telephone plant, on local and toll cables, at the rate of about 700,000 each year, and that rate is expected to continue for some time. On the basis of this demand, the de-



Fig. 5—Cast-iron cases each containing 200 loading coils: left, permalloy-core coils, weight 725 pounds; right, iron-core coils, weight 1750 pounds

velopment of a loading coil with powdered-permalloy core results in a very substantial saving in first cost. The new loading coils are the full equivalent of the old, and in certain respects, notably as to freedom from magnetization and modulation, are decidedly superior.

To those concerned with development and research, however, this coil is not the final word. Though inaugurating a new era in loading today, it represents but another step in advance of the many that have preceded it. In its turn it will no doubt be superseded as our continued experimental work points the way to further improvements in the future.



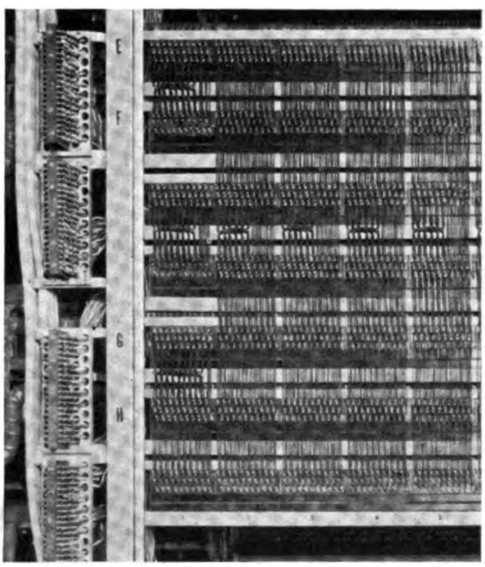
The head, and two of the pioneers, of the Bell System: left to right, Robert W. Devonshire, first employee of the System and since 1913 Vice-President of A. T. & T.; President Gifford; and Thomas A. Watson, who assisted Alexander Graham Bell in his telephone experiments. The picture was taken on the occasion of a testimonial dinner to Mr. Devonshire on August 17, 1927, celebrating his fiftieth Bell System anniversary

New Step-By-Step Equipment

By E. H. SMITH
Systems Development Department

As our cities grew in population it became necessary to group more people and larger numbers of activities in the same space. The one- and two-story buildings began to grow into five- and six-story buildings and the engineer and the architect were called in to investigate the problems that came with this grouping. Engineering skill and ingenuity responded to this demand by bringing into being the modern skyscraper. Much of the progress of the country can be traced to instances in which the engineer made two things grow where one had grown before.

The growth of business enterprise concentrated in small areas has resulted in increased expansion of the telephone plant and it has become necessary to adapt the central office equipment to the skyscraper idea. The equipment design of the step-by-step machine switching system has recently been developed to fit in with this tendency and large savings in building space are resulting. The selecting mechanism for routing a call through an exchange area is mounted on structural iron frames which were formerly nine feet high and were designed for buildings found in the various localities; in many instances they were placed in quarters rented in commercial buildings and even in dwelling houses. It is obvious that a frame designed to meet so many building conditions could not, in the nature of things, be economical for all of them, and it follows that the use of this kind of structure in the modern telephone building is generally wasteful.



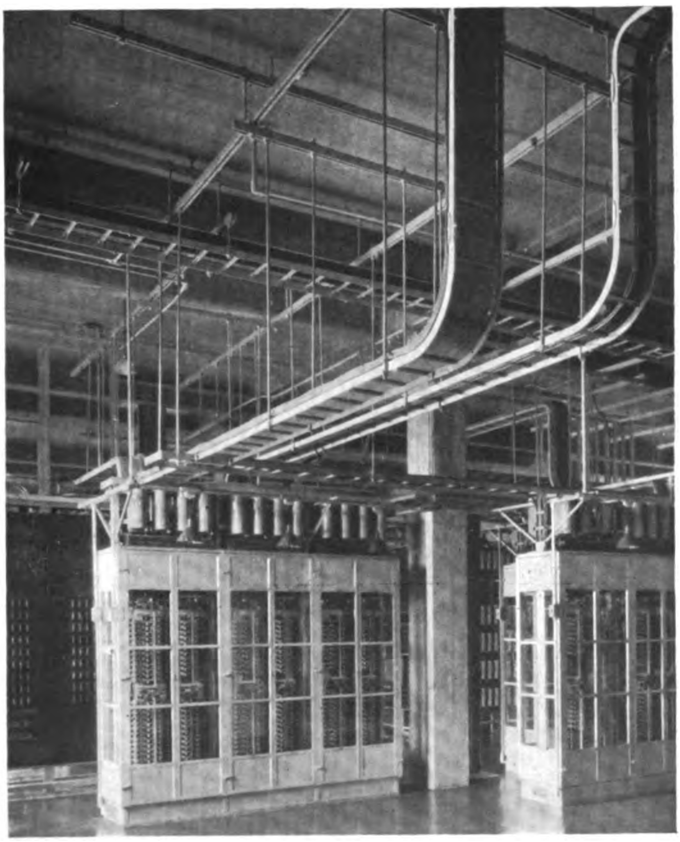
Part of a distributing terminal assembly, showing strap wires used instead of jumpers to group many switches on a small number of trunks

Extensive investigation in building design for telephone equipment has resulted in the establishment of fundamental dimensions for column spacing and ceiling height to which the equipment engineer has adapted the supporting structure for machine-switching apparatus. The clear ceiling height is

twelve feet six inches and the step-by-step selector frames, relay racks and distributing frames have now been redesigned to a uniform height of eleven feet six inches. This allows one foot above the frames to care for the interconnecting cables. Clearly, the eleven-foot-six-inch frame uses the available content of the modern telephone building more efficiently than was possible with the nine-foot frame.

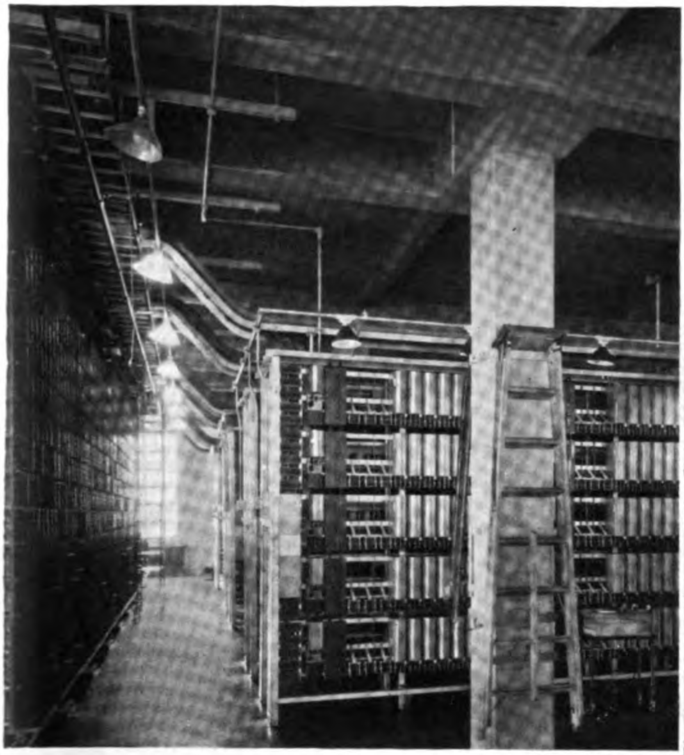
Although increasing the height was the primary consideration, other improvements were incorporated in the new frames: better methods of wiring, greater accessibility of the equipment for installation and maintenance, more uniformity with other systems. The changes also have promoted the practical and economical handling of the equipment from a job-engineering and a merchandising standpoint. To obtain these improvements not all of the capacity gained by increasing the height of the frames could be turned into net saving, but part had to be sacrificed to gain other advantages somewhat less tangible but of great importance to the system as a whole.

The low-type frames for selectors, repeaters and connectors consist of two bays or groups of shelves mounted on supporting frameworks and placed back to back. In the case of the selector frames, a means of terminating and distributing the trunks of the multiple banks known as the distributing terminal assembly closes one end of the space between frameworks. The selector frames mount six shelves, the repeater eight and the connector five shelves per bay. The new high selector frames mount eight shelves, the repeater frames twelve shelves, and the connector frames seven shelves per bay. Instead of being placed back to back, the two bays of the selector frame are in the same vertical plane with the distributing terminal assembly between them. The



Installation of 9-foot frames under a high ceiling at Reading, Pa. Length of the hanger-rods tells its own story

repeater and connector frames are single-bay structures and are located in an office layout end to end in line, thus giving the step-by-step office parallel



Old-type connector frames at Reading, adjoining a distributing frame of standard height

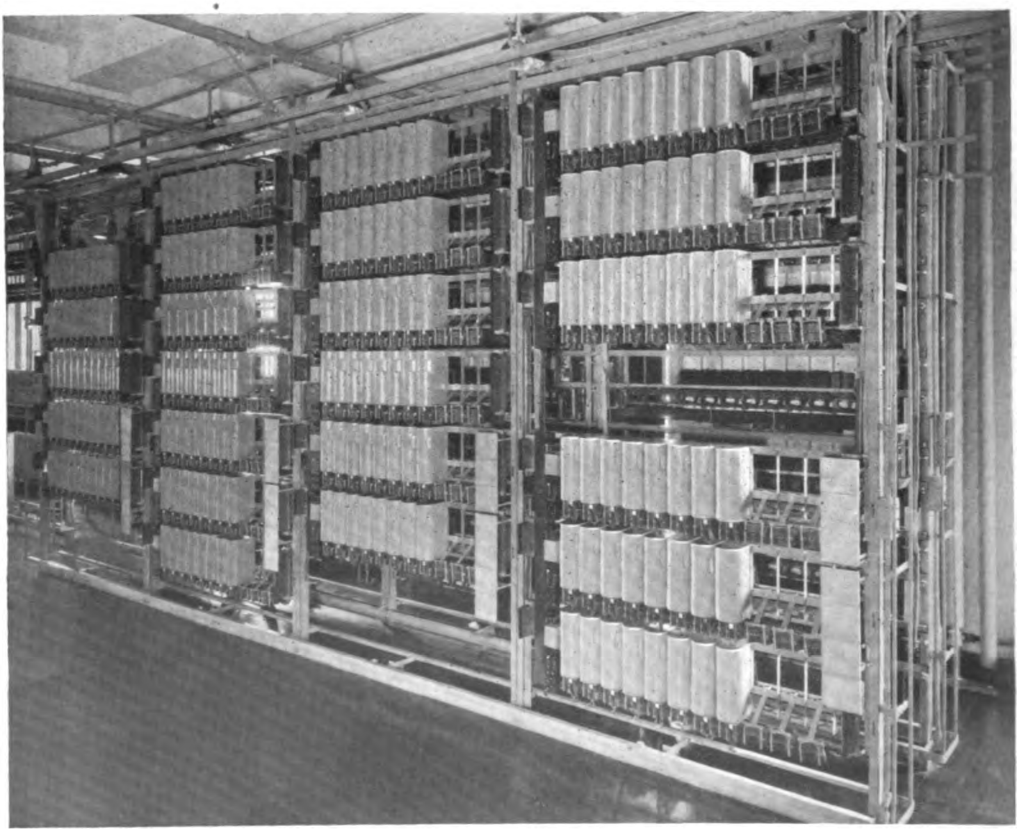
lines of single-sided frames. The wiring sides of these frames are placed facing each other with an aisle between them. Since there is little maintenance required on the wiring side, the aisle space allowed is sufficient to permit the maintenance man to work without cramping, but the aisle is not wide enough to be used as a thoroughfare. However, a wider aisle is used on the apparatus side where the bulk of the maintenance work is done. In the case of the double-sided nine-foot frames there was, under the worst conditions, less than twelve inches aisle space between the apparatus on the inner or wiring side. This made the wiring, particularly the distributing terminal assemblies, very inaccessible. With the frames in a straight line and the minimum of one foot eight inches between the guard rails the accessibility of the equipment has been very much improved.



Two of the first high-type selector frames, as installed at Springfield, Mass.

Notwithstanding the increased aisle space, floor plans of various offices, which were laid out with the new frames, showed an average saving of twenty per cent in the space required for the frame equipment. In some cases this saving ran as high as thirty per cent. An important result is that the use of high frames will often postpone large investments in additions to existing buildings. In one instance it was found possible to place three central-office units in a building where only two units of the old-type frames could have been installed. There are also many intangible savings in floor-plan space, as illustrated by the fact that at one of the earlier offices the Telephone Company's engineers desired to place two complete units on a single floor for economy in cabling and maintenance. They could not have done this using nine-foot frames but did accomplish it by installing the high frames.

The economy of this design is reflected in the Associated Companies' orders for high frames for additions to existing central offices. In the original plan it was not proposed to use the high frames extensively on additions except where the originating unit was small in comparison to the ultimate office and where the present floor plan lent itself readily to the use of the high frame. Changing the floor plan of an office generally involves some cabling difficulties and complicates the alarm equipment and maintenance and is, therefore, not resorted



High-type connector frames under a high ceiling at Springfield

to unless other substantial economies may be realized. There have been a number of cases, however, where the use of the high frames on small additions made it possible to care for the equipment without additions to the building. A saving of twenty per cent in floor space also represents a saving in cabling, since the frames and equipment can be mounted nearer other apparatus to which they are cabled. The line finders and connector frames, for example, may be grouped nearer to the intermediate distributing frames; the associated cable runs are the most expensive in the office.

The high frames of course require rolling ladders for maintenance work since fifty per cent of the equipment is out of reach of a man standing on the floor. However, it has always been necessary to maintain one-third of the low-frame equipment from a stool or some form of portable ladder. It is rather difficult to express quantatively the relative convenience of the two schemes, but it is believed that experience in the field will show that the easy accessibility of the frames will offset the disadvantages inherent in the use of rolling ladders.

The more accessible arrangements of the distributing terminal assembly has greatly facilitated the interconnection of punchings by means of strap-wiring. These connections are often very complex, since they serve to distribute the traffic by giving any desired number of selectors access to a group of trunks.

Although the floor-space saving will be the major economy resulting from the use of the high frames, there are other not inconsiderable savings. Each of the shelves to be mounted on the frames consists of a fully wired unit with the local cables connected to the terminal strips in the factory. The installer's work is thus reduced to a minimum since he is only required to erect the framework and connect the switchboard cable to the terminal strips. Any shelf can be mounted in any position on the frame, and without re-forming cables after the remaining units have been installed. The flexibility inherent in shop-wired units makes quicker installation of the equipment possible and the rearrangements for additions comparatively simple.

The first step-by-step machine-switching office using these new frames was placed in service at Sioux City, Iowa, on May 1, 1927. A number of offices of this type are now being installed and all new offices will make use of these improvements.

The Life History of an Adsorbed Atom

By JOSEPH A. BECKER
Research Department

WHEN one substance is held on the surface of another it is said to be *ad*sorbed; if it penetrates into the interior it is *ab*sorbed. This article tells the story of what happens to an atom of, say, caesium or thorium when it strikes the surface of a tungsten filament.

In the telephone business we are interested in the story because adsorption phenomena play a vital part in the oxide-coated filament which we use in most of our vacuum tubes. This filament, while it is the most efficient and most generally suitable filament for commercial purposes, represents a complex case of adsorption and electron emission phenomena. Hence it is desirable to study simpler types of filaments in which adsorbed particles make it easier to boil out electrons. Our interest in vacuum tubes is so great that we cannot afford to neglect anything which promises to give us cheaper electrons. To free these electrons it is necessary to heat the filament. Practically all this heat is wasted energy. For the same amount of this wasted energy, a tungsten filament whose surface is covered with thorium will yield 100,000 times as many electrons as the clean tungsten filament; and if the surface is covered with caesium this yield is 100,000,000,000,000,000,000 (1 with 20 zeros after it) times as great. Little wonder then that the habits of such adsorbed atoms should be studied.

The chemist is interested in adsorbed atoms because they are the keystone to catalysis. The mysterious phenomena of catalysis are bound to play an increasingly important part in the history of civilization. By means of it new and useful compounds will be made; our food and fuel supply may be augmented. Even now we depend on catalysis for many essential products.

The research physicist is interested in adsorption because it opens up a new world of study. The physicist knows a good deal about the structure of the atom, how atoms behave in the gaseous state, what they do in the solid and liquid states. Until recently what happened on the surface was little understood. The study of the emission of electrons and positively charged ions from the surfaces of hot bodies has given the physicist a powerful tool with which to pry open the secrets of this new surface world. Due to this study, a good deal of which has gone on in our laboratories, a fairly complete picture of this new world can be given. When a caesium atom strikes a clean tungsten surface it is ionized, that is, it gives up its valence or outermost electron to the tungsten and becomes positively charged. This exchange takes place because the tungsten surface has a greater affinity for electrons than the caesium atom. The

positively charged ion induces a negative charge on the surface and since the distance between them is about two one-hundred millionths centimeters the electrical field between them is simply huge—larger than any that man can produce—and the caesium is held by very strong forces. In fact it will stick to a tungsten surface at a temperature of 800 degrees C. for an appreciable time, even though solid caesium at this temperature would explode with terrific force and become a vapor.

The strong electrical fields produced by the adsorbed caesium are in such a direction as to help pull electrons out of the tungsten. That is why such an enormously greater number of electrons boil out of caesiated tungsten surface than out of the clean tungsten surface. Of course, after the tungsten surface is completely covered no more electrons can be pulled out of it and the electrons must come from the caesium itself. This explains the rather startling fact, shown by experiment, that electrons are more easily obtained from partially caesiated tungsten than from thickly covered caesiated tungsten or from pure liquid caesium itself.

Since these strong fields are in a direction to help the negative electrons escape from the surface we should expect that they would hinder the escape of *positive* ions. Here again experiments beautifully confirm the hypothesis and show that if a few caesium atoms can be made to stick to a hot tungsten surface the rest stick more easily.

Of course, if the temperature is too high the caesium atoms that strike the surface will not stay very long, but they stay long enough to give up their valence electron and then they evaporate as ions. Under these conditions every atom that strikes the surface comes off as an ion.

If the temperature is lowered somewhat, a few caesium atoms stick, then the rest stick more readily; in fact for a while every atom that strikes sticks until about one-fourth of the surface is covered. By now the affinity of the surface for electrons has been partially satisfied and hence not every atom that strikes is ionized. Experiments show that in this condition both atoms and ions evaporate.

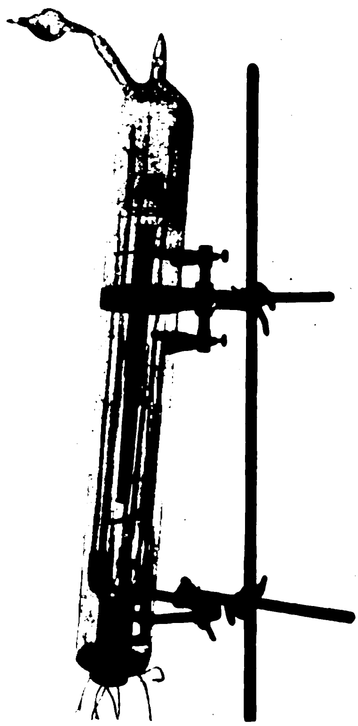


C. J. Calbick and J. A. Becker with the apparatus which yields information on adsorption phenomena

If the temperature is lowered still further, the surface is covered still

more and now only atoms evaporate. If the temperature is low enough the surface is more than completely covered.

These evaporation characteristics were deduced from a long series of experiments which revealed the number of atoms that were adsorbed under various conditions and how this number was related to the number of atoms and ions that evaporated at various temperatures. When one reflects that atoms are so small that we can never hope to see an individual one and also that they are uncharged and hence cannot be measured as a current of electricity, it seems marvellous that experiments should exist which permit us to practically count the atoms that are adsorbed.



This complex vacuum-tube is used to study adsorption of caesium on tungsten

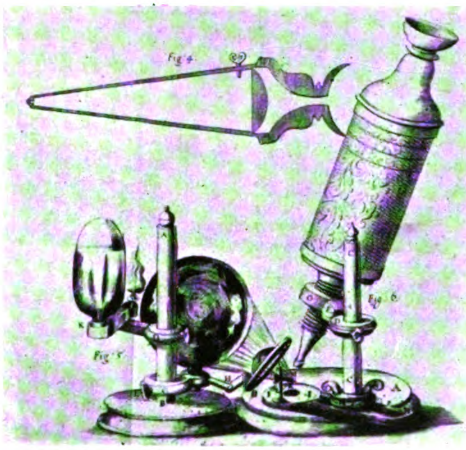
A life history would be incomplete if it did not tell how long an adsorbed atom stays on the surface. Of course, the length of life depends on the temperature; due to the strong electrical fields by which one atom or ion influences others, the life also depends on the number adsorbed. These two factors determine the life; and if the adsorption characteristics mentioned above are known, the number of seconds that an adsorbed atom spends on the surface can be deduced. Thus at a temperature of 500 degrees C., at which an object is just visible in a dark room, and when the surface is half covered, an atom will, on the average, stay for 40 seconds. This life is about a million times as long as that for a caesium atom on bulk caesium at the same temperature.

Finally, a life history should tell us whether or not an adsorbed atom moves over the surface and if so how far. Heretofore chemists, who have done most of the work on adsorption, have assumed that adsorbed atoms are held most firmly by the "active centers" in a catalyst and that these were the edges and corners of the surface crystals. The experiments with caesium and other adsorbed substances show unquestionably that the atoms are not bound to any one spot on the surface but that they move about like a two-dimensional gas or like drops of water on a red-hot stove. If an atom were the size of a tall man and were born in New York it might die in Paris after having made numerous side-trips around the world.

A Tour Through the Microscopic Laboratory

By ANNA K. MARSHALL
Apparatus Development Department

WHEN one reads of the struggles of the early microscopists to learn more of the world about them, great admiration for their courage is aroused. They had at their disposal no such array of apparatus as has the present-day worker; in fact, they had to begin by making their own microscopes. Nor had they the public's support and confidence; their work was not completed until by diligent showmanship they had proved to a hard-headed world the new facts they discovered.



Hooke's Microscope, a striking contrast with the precision instrument of today

For some reason every early worker in this field labored long and diligently in a "dusty, stuffy room." That seemed to be considered a necessary part of such work. With what awe those men would look upon the spacious, shining quarters utilized for a microscopic analysis laboratory in our Bell Telephone Laboratories! Housed on the court side of the recently built steel frame and masonry structure, this laboratory has the unique privilege of having every inch of its rooms arranged in exactly the manner most desirable for easy and efficient use of the apparatus.

By the arrangement in the new laboratory there is an absolute separation of work, three phases being recognized as essential. There are three rooms,—the preparation room in which specimens are prepared for their subsequent study under the microscope; the operating room in which the various kinds of microscopes are placed for the study of specimens; and the darkroom for completing the pictorial proof of the observations made in the microscopic researches.

The preparation room is a complete laboratory in itself. Here the specimens are cut, ground, polished, etched and heat-treated as the case requires. This insures the microscopic apparatus in the operating room against all dust or acid fumes. The principal materials examined are metals, although as has been told* pre-

* Bell Laboratories Record, *Feb.*, 1926, *p.* 235.

viously, many telephone materials find their way into this laboratory for one reason or another. With the metals, as with any other work, it is a matter of experience to be able to prepare them easily. Here is at hand most modern apparatus for the purpose.



H. A. Anderson preparing to cut a specimen of lead cable sheath on the microtome

Those specimens which are too large for the purpose of examination are placed in a power hack-saw which cuts through a specimen, then automatically stops. The next step is to grind a flat surface. Very hard metals require the action of a coarse abrasive. And since this is a long process if done by hand, recourse is had to an electrically operated grinding wheel. The friction of two surfaces rubbed together causes heat, which is an unwanted factor during this operation since heat tempers metals, and their structure is thereby changed. To remove this heat, a stream of cold water is run over the specimen throughout the grinding process. This grinder has two wheels, a very coarse alundum wheel on one side and a finer wheel of emery on the other side. The latter is used for cutting specimens too hard to be cut with the power hack-saw. When the specimen has been sufficiently flattened, it is then carefully ground down by hand on abrasive papers of successively finer grades. Each paper is used for a period long enough to insure the removal of the coarser scratches made by the previous paper. During this work, the surface of the specimen must be kept perfectly flat. The abrasive papers are therefore



R. R. Ziegler puts the final polish on a steel specimen

laid face up on the plane surface of a heavy metal bench plate. After this process, the specimen is ready for polishing on electrically run discs, of which three are in use. In case the

specimen must undergo a heat-treating process before it is polished for examination, both an oven and a furnace are available in the laboratory.

Another piece of apparatus in the preparation room appeals to general interest. It is a microtome of sturdy construction primarily intended for the sectioning of wood for microscopic study, but introduced by this laboratory into the role of a metal-sectioning apparatus. That is, soft metals such as lead, gold, aluminum, and copper are cut with a specially honed knife and in this way prepared for etching much more easily and with much clearer and more accurate results than by polishing.

After metal is either polished or cut, its structure can be brought out for study by the application of acids. The etching is carried on under a fume hood which is equipped with an electric blower to carry off all acid fumes as quickly as they rise, thus safeguarding the health of the workers as well as preserving the apparatus from the injurious effects of the acids.

A viewing microscope is kept in the preparation room and is used to watch the progress of the preparation of specimens. This microscope has an historical interest in being the first one used for successful high-power photomicrographs.

The other laboratory, which for convenience is called the operating room, is more than three times as large as the preparation room. Here are the microscopes of various kinds on which studies of the materials are made. If a large specimen is to be examined as a whole, it is placed on the outfit known as the gross metallurgical outfit which does not include a microscope at all but has a large stage for holding the specimen while it is viewed through low-power lenses up to a magnification of about thirty-five times.

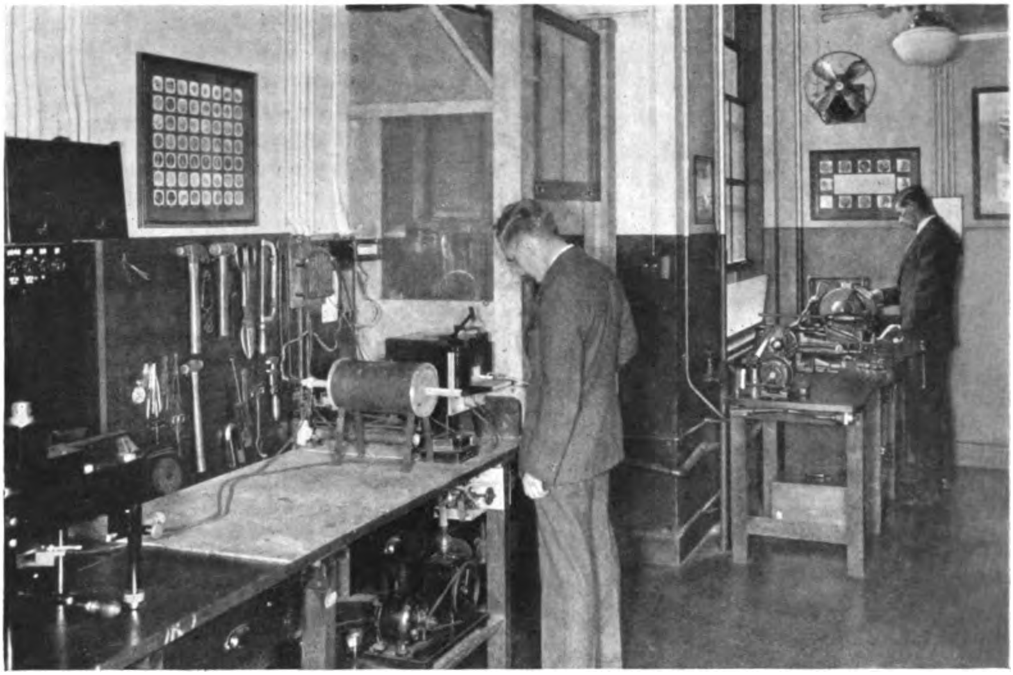
For studying specimens that must be magnified higher—from fifty to six thousand times—a metallurgical microscope is used. The combination of lenses, eyepieces and bellows-extension gives the desired magnification.



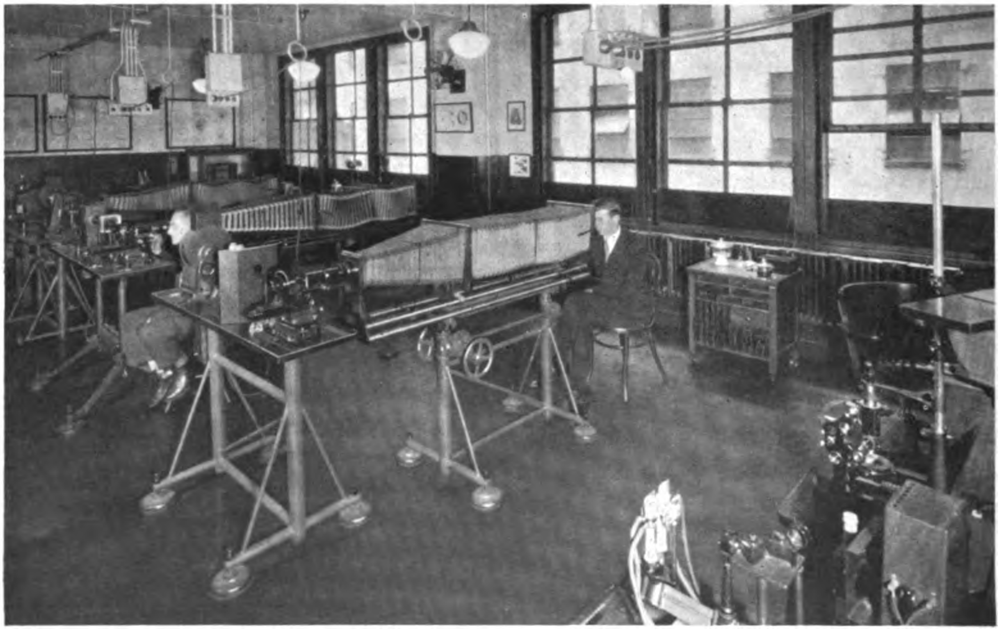
R. M. Sample uses the micro-manipulator

The crystalline structure of metals and metallic alloys is studied in minute detail; conclusions are drawn as to the causes for defects in metals; changes are seen due to various treatments of the metals; and improvements are suggested.

The layman thinks of a microscope in terms of magnification or enlargement of the optical image over the dimensions of the object. He disregards the matter of resolution which denotes the ability of the microscope to "resolve" or produce sharp images of very small particles. It is known that by decreasing the wavelength of the light used, resolution



One corner of the preparation room. Mr. Sample about to place a specimen in the electric furnace; at the grinding wheel, Mr. Ziegler prepares a flat surface on a very hard specimen

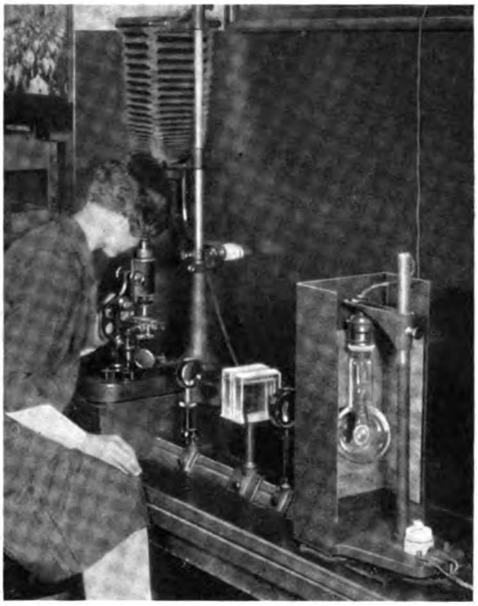


The operating room with its array of microscopes. In the immediate foreground is the ultra-violet equipment

may be improved. This fact led to the development of the ultra-violet microscope which utilizes very short wave-length light. Ultra-violet light is below the visible spectrum and consequently the eye cannot visualize with this light. In this microscope all optical parts are of quartz, as glass is opaque to ultra-violet light. The successful use of ultra-violet light on metallic specimens is a development of this laboratory.

The ultra-microscope is used for the study of colloidal solutions in solid or liquid form. A colloidal solution may be briefly described as one in which very small particles of matter are dispersed in a medium. The dimensions of the particles are usually considered to be sub-microscopic. The actual particles are not observed but their presence is made known as bright points by the light which they scatter. The colloidal solution is intensely illuminated and these particles shine brilliantly the same way that dust particles floating in the air of a darkened room are made visible by means of a beam of sunlight.

A microscope for viewing transparent objects is used for the study of such materials as wood, paper fibers, and porcelain. It was by this means that some interesting features of the microscopic structure of rubber were recently brought out.



Miss Marshall adjusts the microscope before photographing a timber section

Provision has been made for studying the effect of heat upon metals during the actual heating process. This is accomplished by means of the heat-microscope, a novel combination of furnace and microscope. The specimen to be investigated is placed in the small furnace, the heat turned on and a watch kept on the specimen by means of the microscope which is attached in such a position that the surface of the specimen is directly in the view of the observer.

Other apparatus in the laboratory includes the micro-manipulator, a delicately made affair for dissecting small specimens with the aid of the microscope. Its motion is made possible in any direction and for unbelievably short distances by means of small screws to direct the movements. In this way microscopic materials may be treated quite as though they had the size of visible materials. The micro-character tester makes a fine line along a metallic specimen; by the study of this line under the microscope one can see the relative differences in the hardness of the crystals which make up the materials under observation.

The dark-room is divided into two parts, and quite illogically, it would

seem, there are no doors. Entrance is through a maze which effectively cuts off light from the first part, a room used only for the printing process. Another maze with black curtains leads from this room into the developing room where the plates are developed. Thus both printing and developing can be carried on at the same time without interruption or delay to either.

The photomicrographic laboratory is internationally known for its developments by F. F. Lucas, in the field of high-power metallography.

When this laboratory speaks in terms of high magnifications, it limits itself to the point at which it is able to obtain perfect detail and resolution. Its province is not merely to magnify to great power, but at the same time to obtain results which can be read by those who know the language of the photomicrograph. Highlights and shadows on the photographic print are full of meaning to the investigator as guide posts in his search for more serviceable and more economical materials for the Bell System.

An Official Appreciation

Assistance rendered by the Bell System to the Canadian Government in effecting a tie-in of Canadian broadcasting stations for the Diamond Jubilee Celebration has been acknowledged by Premier W. L. Mackenzie King in the following letter to President Gifford:

"The broadcast of the official ceremonies at Ottawa in celebration of the Diamond Jubilee of Confederation was a great success. Speech and music alike were heard throughout Canada and beyond, and grateful reports are being received daily. What began as a daring venture became an outstanding, unifying feature of the National celebration.

"The Government of Canada appreciates greatly the assistance, so readily and generously given by the American Telephone and Telegraph Company, by your direction, not only in counsel, but through the use of equipment and facilities which made possible the application to this National purpose the results of the scientific research by your System, to which the communications of the world owe so much.

"On behalf of the people of Canada who received the message, as well as on behalf of the Dominion Government, I tender appreciative thanks."

Winged Words

NEW York's cheers for Lindbergh were still resounding when the Lindberg Aeronautics Corporation soared into the spotlight. An individual with a name similar to that of the famous pilot was found, this name appropriated, the idea incorporated under the laws of Delaware, advertisements made for stock-selling recruits and preparations made to unload on cheering patriots from $10,000,000 to $100,000,000 of securities bearing Lindberg's name.



© *Underwood and Underwood*

Through Western Electric transmitters, Col. Lindbergh's words start their radio journey

The National Better Business Bureau and those of Philadelphia, New York, Cleveland and St. Louis, acting in concert, obtained and disseminated the facts. The bubble—"There's millions in the Air"—burst, and many good dollars consequently remained safe in the pockets of investors.

To the Better Business Bureau of Cleveland, in which city was discovered the innocent "Lindberg" whose name was taken by the promoter, Assistant Secretary of War Davison wrote:

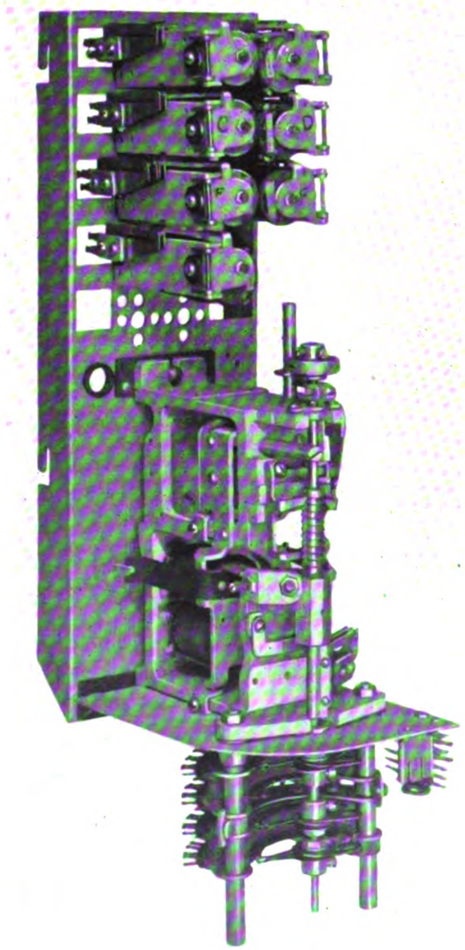
" . . . The history of events shows that whenever some medium of general benefit to mankind is evolved the 'wild-catter' is usually on the job prepared to feast on the gullibility of those who look for quick and big profits."

The Bureau has investigated a large number of "investment" schemes, has published its findings in pamphlets available at its headquarters, 383 Madison Avenue, New York. Among these pamphlets are: Which Way Decimo?; Boston Curb Exchange; Universal Lock Tip; International Transportation Association; Read Before You Sign.

Cutting Expense Corners in Systems Drafting

By W. L. HEARD
Systems Development Department

ONE often hears of the advancements which have been made in photography in the last few years, but few realize the extent to which it is used as an aid to the engineer. Some instances which are universally recognized, of course, are the blueprints and photostats made from the tracings and sketches used by the engineers. These are not, however, the only ways in which photographic processes may serve to simplify the making of intricate circuit and equipment drawings.

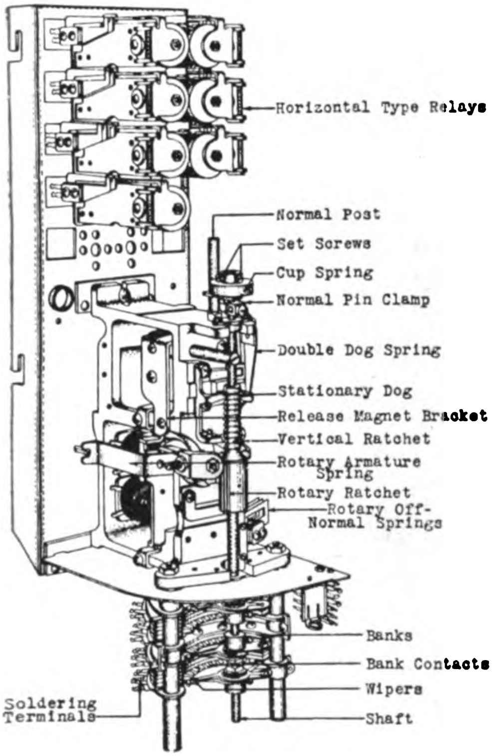


This half-tone was made from the photograph with which the process started

In connection with the preparation of certain of our engineering information, it is desirable to portray certain objects in three dimensions. In making perspective drawings of such things as sequence switches and connectors the amount of drafting time required is quite long and the work exacting. To reduce this time and its resultant costs, there has been developed in the Systems Drafting Department a scheme which has resulted in materially reducing the expense and time of making these drawings. The method used has all the flexibility, both as to change in size or modification of detail, that could be desired. It meets one of the complicating requirements that the drawings be made from one and one-half times to four times the size of the actual reproduction which is placed in our specifications.

The apparatus is first photographed. Over the resulting print a piece of transparent celluloid is placed to serve as tracing cloth. Upon this the photograph is then traced in free-

hand. Celluloid is used because its greater transparency makes it easier to see the details of the photograph. The image on the celluloid is then en-

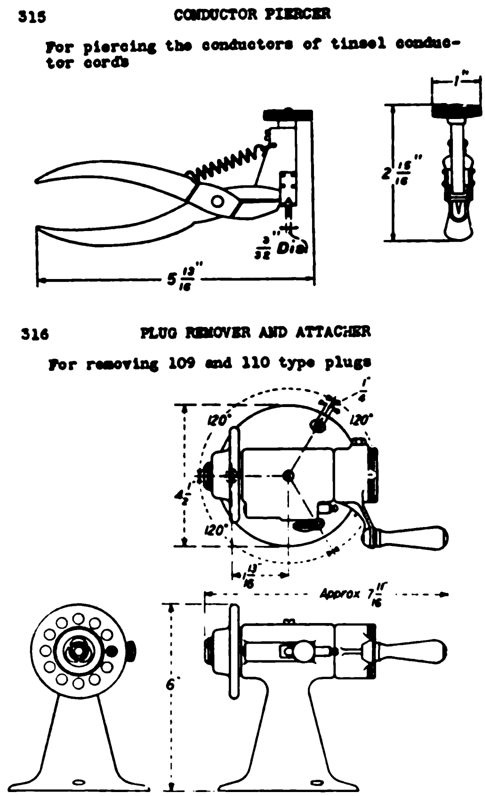


This line-cut was made from the zincographed print which is the final result of the process

larged by making a photostat the desired size. From this photostat the apparatus is traced directly on tracing cloth where the drawing is completed as to details, such as shading, lettering, and marking.

The final step, from the enlarged tracing with the added details and notes to the reduced reproduction that may appear on the specification sheet, is accomplished by a process known as zincographing. This is an interesting process which gives reproductions of sketches, typing, and similar information used in the preparation of engineering data, the only limiting factor being that a legible black and white original must be available.

The first step is to photograph the original or master copy, obtaining a negative on glass or paper, which may be either an enlargement or a reduction as desired. Portions of it may then be blocked out or other



Excerpt from a zincographed specification for cord-repair tools

parts inserted if necessary. The negative is next stripped from its plate or film, put on a large sheet of glass and backed up by a sensitized zinc-plate. This is then placed in a vacuum printing frame and given a brief exposure, after which the plate

is removed, rolled up with ink, and developed. At this stage, the design stands out clearly in black ink on the surface of the plate. Corrections may be made on this plate or designs etched in as required. After these operations have been completed, the plate is ready for printing. The press used has two cylinders, around one of which the zinc plate is bent. This revolves and leaves an impression on a rubber blanket which covers a second revolving cylinder. This latter roller in turn transfers the impression to the paper.

Some of the advantages of the use of this method of printing are the prompt deliveries which can be obtained; from one to three days are required for the usual run of material. Considerable time and effort are also saved due to the fact that copies made in this way do not require elaborate checking, as is the case with material which must be copied or which must be set up on a regular printing press. This process can be used over and over with the same master; and the master copy can be changed again and again by blocking out and patching.

In the Systems Development Department, all specifications are now prepared by this method; and drawings and other data are furnished on this basis wherever the number of copies required will make the expense of this reproduction justifiable. Where a large number of copies are needed, which is often the case, this method is cheaper than blueprinting. Ordinary paper is used and the cost is not much more than that of the paper itself. With blueprints, on the contrary, there is little reduction in price due to quantity production since the sensitized paper is the main item of cost. In our Systems Department, over three million pages of such zincographed copy are produced a year, and these find distribution to all parts of the Bell System.

Some Bell System Statistics

Thirty-three machine switching offices are now in service in New York City, to which three hundred eighty thousand telephones are connected out of a total of two million two hundred thousand Bell-owned dial stations. These in turn are a sixth of the Bell stations, and almost an eighth of all telephones in the country.

The Bell System owns about three-fourths of the nation's telephones, nine-tenths of the wire used for exchange and toll service and about a third of the central offices. Parent and operating companies employ about five-sixths of the telephone workers.

Stockholders in the American Telephone and Telegraph Company on June thirtieth numbered four hundred twenty thousand, of whom seventy-three thousand were employees. In addition one hundred ninety thousand had purchases in progress under the terms of the Employees' Stock Plan.

Five New Telephone Pioneers

SO far in 1927 five of the Laboratories staff have become members of Edward J. Hall Chapter, Telephone Pioneers of America, an organization of those who early made telephony their life work. Its membership is open to employees of the Bell System or independent companies with twenty-one years or more of telephone experience. The new members are H. L. Bostater, G. W. Folkner, A. D. Hargan, E. E. Hinrichsen and A. W. Lawrence.



H. L. Bostater

Mr. Bostater joined the maintenance force of the Central Union Telephone Company at Columbus, Ohio, immediately after graduating from Ohio State University in 1904. The next year he was transferred to Western Electric at Clinton Street, Chicago, as an equipment engineer, and did almost every variety of work in that field, from writing specifications to supervising the standardization of circuits. In 1912 he came to the circuit laboratory here for development work on semi-mechanical call distribution. In 1915 and 1916 he worked on step-by-step equipment, and from 1917 to 1922 was in charge of its development. Since then he has been engaged in system development and cost estimate investigations.



G. W. Folkner

In February of 1906 Mr. Folkner started at West Street as a draftsman, and stayed until 1909, when he was moved to Hawthorne with the organization for manufacturing relays, drops and signals. In 1915 he was transferred to the technical end of panel machine switching development, at which he remained until the first three trial installations were in service, in Newark. Then, in 1915, he came back to West Street, to fit the designs of panel apparatus to the requirements of commercial manufacture.

Mr. Hargan entered the telephone business at West Street in 1906, in the switchboard section of the manufacturing organization. From 1913 to 1916 he was at Hawthorne in connection with switchboard manufacture; then he came to the engineering department at West Street for work on panel machine switching apparatus, in which he is now engaged.

Mr. Hinrichsen's experience start-



A. W. Lawrence



E. E. Hinrichsen



A. D. Hargan

ed earliest of this group, in September, 1901, for the Central Union Telephone Company. He worked all over Illinois at plant work of nearly every sort. In the spring of 1905 he went to the Interstate Telephone and Telegraph Company, an independent company at Aurora, Illinois, where he stayed a year. With this background of field experience he entered the equipment engineering section of Western Electric at Clinton Street, and later moved with it to Hawthorne. In the fall of 1908 he was moved to the circuit laboratory at West Street, and stayed there until his health made a rest necessary, in 1917. After returning he continued his former work, but in the present Systems Development Department, which had just been organized.

Mr. Lawrence's entire telephone career has been at West Street. He entered the engineering inspection section in the spring of 1906, and later was engaged for many years in design of special apparatus and modification of standard apparatus for specific field conditions. He is now in charge of special orders and of specifications for testing and laboratory apparatus, and for all telephone apparatus except that used in machine switching.

News of the Month

AT THE CENTENARY EXHIBITION of the Baltimore and Ohio Railroad, to be held near Baltimore from September 24 to October 8, the American Telephone and Telegraph Company will exhibit a telephone train dispatching system in operation, and representative telephone devices from the first switchboard to the latest developments of the Laboratories.

* * * *

RADIO ENGINEER E. P. HENTSCHEL and JUNIOR PHYSICIST J. D. WALLACE, JR., of the Naval Research Laboratory, were recent visitors to the Laboratories.

* * * *

S. P. GRACE has been appointed a member of the Committee on Communication and of the Board of Examiners of the A. I. E. E.

Mr. Grace described some recent research work of the Laboratories on July 15 at the Tri-State Conference of the New York, Pennsylvania and Ohio Independent Telephone Associations held at Jamestown, New York.

* * * *

JOHN MILLS delivered a demonstration lecture at Chautauqua, New York, on July 19, accompanied by the film "The Magic of Communication" and illustrated by a public-address system and a set of head phones for those with impaired hearing. Mr. Mills was assisted by R. E. Kuebler, who had supervised installation of the demonstration equipment.

* * * *

R. V. L. HARTLEY and O. E. BUCKLEY sailed aboard the Baltic on August 20 for Liverpool. From there they went to Leeds to attend the meeting of the British Association for the Advancement of Science, held from August 31 to September 7. September 10 to 15 they plan to attend the Technical and Scientific Congress of Telephony and Telegraphy to be held in connection with the Volta Centenary and Exposition at Como, Italy. Mr. Hartley is to read a paper on "Frequency Relations in Electrical Communication" and Mr. Buckley a paper on "High Speed Ocean Cable Telegraphy."

* * * *

F. F. LUCAS is to present a paper, "A Resume of the Development and Application of High-Power Metallography and the Ultra-Violet Microscope," to the International Congress for Testing Materials at Amsterdam on September 12. While in Europe he is to visit the Carl Zeiss optical works at Jena for a conference of a week or more with their scientific staff on development of new high-power photomicrographic equipment. He has been invited to attend a conference with the staff of R. Jung Company, Heidelberg, on preparing metallic specimens with a microtome, and to visit the Leitz works at Wetzler, Germany. Before returning he

will visit metallurgical works and laboratories in Germany, Holland, France, Belgium and England.

* * * *

W. L. Tierney recently visited broadcasting stations using Western Electric equipment at San Francisco, Tacoma and Seattle. He is now supervising installations of a one-kilowatt set for the Gurney Seed Company at Yankton, South Dakota.

Operation of the five-kilowatt transmitting station installed under supervision of H. S. Price for the Stromberg-Carlson Telephone Manufacturing Company at Rochester, New York, is scheduled for the early part of this month.

W. L. Black is in charge of installation of elaborate speech-input and control systems at the Sagamore Hotel and the Eastman School of Music for use with the broadcasting station.

On July 27, F. S. Bernhard completed installation of one-kilowatt broadcasting equipment for the Milwaukee *Journal.*

H. R. Kimball was at Hawthorne during August installing and testing a test set for measuring the reflection coefficient on single channel carrier telephone systems.

From July 17 to 26 F. B. Monell was at Hawthorne in connection with equalizers for the reproducers of Movietone equipment.

E. Montchyk and J. T. Butterfield were for a time in Boston for the study of 1-A bearings, used on the driving shafts of machine switching frames.

H. N. Van Deusen, J. R. Townsend and H. G. Arlt spent the week beginning August 1 at Hawthorne for conferences regarding specifications for sheet metals, standardization of screw threads and standardization of metal finishes.

H. S. Smith is now at Hawthorne in connection with the development of a special cord for use with dial telephones.

B. Friele was in Utica, New York, August 11 in connection with modification of frames and covers for step-by-step switches.

* * * *

W. A. Boyd, H. F. Kortheuer and R. M. Moody recently attended Inspection Survey Conferences at Hawthorne. Similar conferences at Kearny were attended by H. F. Kortheuer and T. Mellors.

E. F. Helbing went to Springfield, Ohio, in connection with new gasoline equipment for type "T" engines made by the Foos Gas Engine Company. During the latter part of July he visited the factory of the Midwest Air Filters, Incorporated, at Bradford, Pennsylvania, to inspect equipment used in testing air-filter units.

During the second week in July, P. B. Almquist, Local Field Engineer for the Inspection Department at San Francisco, was in Portland and Seattle in connection with field work in his territory.

* * * *

C. H. Amadon was in Brookline, Massachusetts, during August for

some timber preservation experiments.

ON JULY 29, E. St. John witnessed impact tests on steel manhole covers at the factory of the Central Iron and Steel Company in Harrisburg, Pennsylvania.

E. M. HONAN and J. B. DIXON visited the American Brass Company's plant at Ansonia, Connecticut, on July 26 and 27.

* * * *

J. L. DOW, E. H. SMITH and D. H. WETHERELL attended the cutover of the new step-by-step machine-switching office at Springfield, Massachusetts. This is the first such office entirely of Western Electric manufacture.

MODIFICATIONS in picture-transmission equipment are being tested by C. E. White and E. P. Bancroft at Chicago and San Francisco, respectively.

R. H. MILLER visited Albany, Buffalo, Syracuse and a number of other cities in connection with methods of toll operation.

H. H. SPENCER spent several days at Manchester, New Hampshire, testing telegraph ground-potential compensators.

A. R. KEMP and C. L. HIPPENSTEEL were at Providence, Rhode Island, August 9 to 12, to inspect the rubber compression testing machine which is being built for the Laboratories by the Henry L. Scott Testing Machine Company.

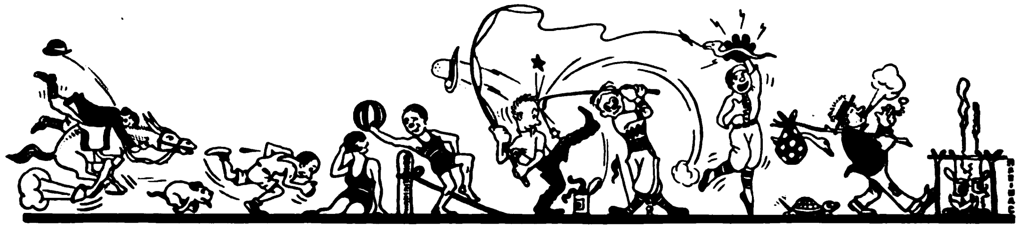
H. BOVING returned to the Laboratories on August 15 after spending three weeks at Hawthorne on the development of enameled wire.

R. M. BURNS left for the Pacific Coast on August 12, where he is to spend two months visiting Seattle, San Francisco and Los Angeles investigating cable sheath corrosion and examining samples that were set in the field last year.

R. E. WATERMAN went to Boston August 11 to visit Montan, Incorporated, in connection with some wood preservation tests.

H. A. LARLEE and W. G. BREIVOGEL recently returned from Hawthorne, where they had been working on problems of manufacture of telephone sets.

F. F. FARNSWORTH recently returned from a two weeks' stay at Hawthorne, spent principally in work on simplification of metal finish practice.



Club Notes

THE 1927-28 bowling season will open on Friday evening, September 30, at Dwyer's Manhattan Alleys, 1680 Broadway, the same place which was used for the 1926-27 tournament. The league will be divided into three separate groups; a fourth will be organized if demand is great enough; placement of the men in the individual groups will be based on their average for the previous season. For the past four or five years the league has been composed of twenty-four teams, but now the number of men desiring to bowl as regulars is increasing. It will be possible to engage twenty-eight alleys instead of the usual twenty-four if enough men are interested, and so it is hoped that those who have not yet filled out their application blanks will do so at once to enable the committee to complete their arrangements. Those who have not received blanks should call G. A. Brown on Extension 881.

A new feature in the contract for this season is free instruction to league members given by a prominent bowler of national reputation, between the hours of noon and 2 P. M. from Monday to Friday. A committee will be appointed to arrange in advance for this instruction, and to decide on the hour and day for our league members. A bowler receiving instructions will be charged the regular bowling fee of twenty-five cents a game.

This year a gold medal will be given to the bowler making the high score rolled in each group, instead of one medal for the high score in the three leagues.

Success of the league depends greatly on the number of substitutes available. Each week some of our regulars are missing and their places filled by men who like to bowl occasionally. It is therefore the desire of the committee to have these men submit their names as part-time bowlers. No previous experience is necessary; our system of handicapping covers everyone who is desirous of bowling whether his average is one hundred or two hundred.

Bowling officers for the 1927-28 season are as follows:

A. F. Gilson, General Chairman.
G. A. Brown, General Secretary-Treasurer.
F. H. Graham, Chairman Group "A."
G. B. Small, Secretary-Treasurer Group "A."
A. G. Eckerson, Chairman Group "B."
B. Leuvelink, Secretary-Treasurer Group "B."
E. R. Smith, Chairman Group "C."
W. H. Berthold, Secretary-Treasurer Group "C."

Golf

The Fall Golf Tournament, consisting of two rounds of medal play, will be held on two Saturdays in Sep-

tember at the Salisbury Country Club, Garden City, Long Island. On September 17 twenty-eight golfers will qualify for the finals, which will be played on September 24. Those qualifying will be divided into two classes, the twelve players with low gross scores in Class A and the remainder in Class B.



In the qualifying round prizes will be given for the two best gross scores and for the two best net scores. Prizes in the finals will be awarded to players having the best gross score and the three best net scores in each Class. Entry blanks must be filed with D. D. Haggerty, Room 164, not later than September 10, accompanied by an entry fee of two dollars.

The golf committee has just completed the revision of the Club handicaps which may be had by calling at Room 164.

Music

The Club orchestra will resume its activities on Tuesday evening, September 27. The orchestra has made steady progress since its organization three years ago, and plans are under way to make the fourth season the best ever. The committee in charge of music is now considering employment of a paid director for the activities of the music group. A hearty welcome will be extended this year to all new members. If you are planning to attend the rehearsals for the 1927-28 season, kindly communicate at once with the business manager, W. A. Krueger, Room 81, extension 798.



Dance

The first dance of the fall and winter season will be held Friday evening, October 7, on the roof of the Hotel McAlpin. The music will be furnished by Deacon Johnson and his entertainers, formerly of the Hotel Astor and the Bellevue Stratford.

Attendance has been limited to five hundred by the management of the Hotel McAlpin, so it is advisable to purchase tickets at once. Admission will be $1.10 each, including tax. No tickets will be sold at the door. D. R. McCormack will manage all of our dances and entertainments for the 1928 season.

Hiking

This month there will be two hikes and two campfire suppers. September 10, the trail leads through Westchester County from Heathcote to Nepperhan, about eight miles, with Phyllis Barton as leader and hostess. Those who are going should notify her. The group will leave the entrance to the new building at 12:30, and the expense will be about a dollar. The other hike will be from Arden to Tuxedo, a distance of about fifteen miles. It will take place on Sunday, September 18, and will be led by T. Temple. Miss Barton would like to hear not later than the previous Friday from those who intend to go. The train leaves the Erie station in Jersey City at 9:00; a ten-ride ticket will be bought for the

group. Total expense, about $2.25.

Two campfire suppers will be held on the Jersey shore, at Englewood, on September 15 with Miss Barton as hostess and along the river on September 27, when Miss Brisbane will be hostess. To enjoy either evening meet at the entrance to the new building at 5:10 and bring along sixty cents.

Athletics for Women

Swimming. Although seashore and lake swimming are most to be desired we certainly have a good time in the pools during the fall and winter months. This year there are to be two classes for the women at the Carroll Club pool, one on Monday evenings from seven o'clock to seven-thirty, and the other a continuation of the spring class on Wednesday from five-thirty to six. Both of these classes will run through a ten-week period; at the end of that time a new class will be formed for those who wish to continue the instruction. The cost will be $2.50 for eight lessons.

Basket Ball. While we are planning a swimming class for Monday nights, this should not in any way interfere with the Basket Ball games which will also be held on Monday nights. This season we are planning to play at the Manhattan Trade School Gymnasium, which is larger than our court last year. We hope that all members of last year's team will come out and many more. Our plans for the season are not completed as yet, but we hope to have plenty of good snappy practice work up to the first of the year and after that to have games scheduled for almost every week to the end of the season. We want everyone interested to sign up because we will need the best players we can get to represent the Club in both the Modified Girls' Rules and the Boys' Rules teams and to do this we will want those who are just starting to play the game as well as those with experience. The best player makes the team. Come out and try for it.

We will also appreciate information regarding any outside girls' teams in order to make up our schedule. If you know of one let Marie Boman know, so that she can get in touch with the manager.

Riding. We still have some tickets available for riding at Unity Riding Academy. These are one dollar and a quarter for one hour's riding. If you would like to try the horses see Marion Gilmartin for tickets.

BELL LABORATORIES RECORD

HEARING AIDS AND DEAFNESS
By H. Fletcher

THE POLARITY OF LEARNING
By J. S. Hartnett

SHORT-WAVE OSCILLATORS
By C. R. Englund

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Bell Laboratories Record

Volume Five — October, 1927 — Number Two

Hearing Aids and Deafness

By HARVEY FLETCHER
Research Department

THOSE of us who are associated with the telephone business are frequently asked questions regarding the value of hearing aids, sometimes miscalled "deaf sets." There is a natural feeling that telephone people should know something about hearing aids because they are essentially miniature telephone systems.

This feeling is strengthened by the knowledge that our Laboratories, as part of the research work which it carries on for the American Telephone and Telegraph Company, studies every phase of hearing, that it investigates such matters as articulation, the relative importance of vowels and consonants in speech interpretation, the influence of loudness, and the characteristics of the ear as an organ of hearing.

These studies are finding numerous applications in the design of telephone apparatus and have also made possible the development by Bell Telephone Laboratories of certain hearing aids. These developments are made available to the public through manufacture by the Western Electric Company under the name "Audiphone," and are distributed by the Graybar Electric Company. When selected with respect to the individual's impairment of hearing and needs these aids give valuable assistance.

Loss of hearing is not a simple matter, not even one that varies in quantity only, but an extremely varying phenomenon that takes many forms. It is comparatively easy to make a hearing aid that is merely a sound amplifier, which to many might seem sufficient, but to make one that will aid the greatest number of deafened people to understand the largest percentage of spoken words requires a knowledge that can be obtained only from extensive studies of hearing and can be applied successfully only by those widely experienced in the art of electrical communication.

There is a level of loudness above which sounds begin to affect the sense not of hearing but of touch, causing a sensation of tickling in the ears which very soon becomes painful. This represents the upper limit of

hearing and is called the "threshold of sensation" since feeling then begins. It is useless to amplify sounds above this point, for were this done the sounds would produce pain and not hearing. At the other extreme there is a level of minimum loudness, referred to as the "threshold of audibility." Below this level sounds are not sensed at all. All speech must fall between these two limits.

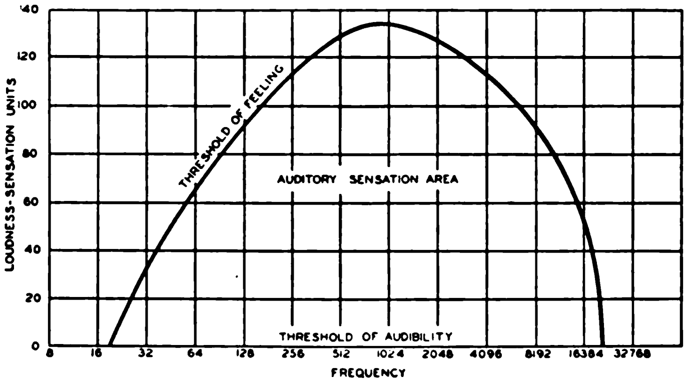


Figure 1—*The two thresholds of a normal ear*

Loudness is conveniently measured in "sensation units" and from the threshold of audibility for normal ears to that of sensation is a range of about 110 sensation units.

The situation is complicated by the fact that this range of audibility is not the same for all pitches. It is less for sounds both very low and very high in vibration frequency. If the threshold of audibility is plotted as a horizontal line with increasing frequencies marked along to the right, the threshold of feeling would be plotted as shown in Figure 1 which gives the average values for normal ears. The entire auditory sensation area which this line encloses normally covers a frequency range from about twenty to twenty thousand cycles per second, corresponding to a range from about three and one half octaves below to something more than six octaves above the note of "middle C." It rises to a peak of nearly 140 sensation units in the neighborhood of a thousand cycles, that is for a sound about two octaves above middle C.

Deafness in any form cuts down this area but it may do so in a large number of ways. The threshold of feeling is about the same for all people whether deaf or not. The effect of deafness is to raise or modify in some manner the threshold of audibility. That base line may be bodily raised so that the area maintains its same general shape but with higher values; or it may be both raised and bent so that the maximum value is moved toward the lower or



The 6332-*A Audiphone as demonstrated by B. A. Clarke. A two-stage amplifier with batteries occupies the box in the foreground*

the higher end of the frequency range.

Sounds of speech as they are normally pronounced differ in loudness. That of "aw" is the loudest of them all, and the sound of "th," as in "thin," is one of the weakest. In general, vowels are loud and consonants are weak; and the difference between them may be as much as thirty sensation units. The auditory area must, therefore, be at least thirty sensation units wide if all vowels and consonants are to fall within it. When it is narrower than this, no hearing aid can be of much assistance as the auditory area could not then include all spoken sounds. If the weak consonant sounds are amplified so that they fall within it, the louder vowel sounds would at the same time be raised above the threshold of feeling and become unendurable, while if the vowels were kept satisfactorily low the consonants would be inaudible. An improperly designed hearing aid might actually raise the vowel sounds more than the consonants, which would have the effect of aggravating this situation.

Due to the fact that partial loss of hearing means a modification of the auditory area in a different manner for each individual, it might seem that a perfect set would be one designed especially for each case. Practically, however, this would make the sets so expensive that they would be beyond the reach of most of those who need them. Fortunately such an extreme is not essential for with sufficient knowledge of the circuits that are used so generally in telephone work, one can make a standard set approaching the desired perfection.

Noise, however, is a factor which forcibly enters any hearing problem. Obviously amplifying speech sounds amplifies noises also. Improper design might even cause a set to amplify slight noises more than ordinary sounds and thus to be inexcusably noisy. Noise also limits the range of a hearing aid. The greater the distance between a speaker and the hearing aid of a listener the greater will be the effective amount of noise which



The 6034-A Audiphone requires no vacuum tubes. In the case are the transmitter and batteries

the set will pick up and so the poorer will be the result. A considerable experience leads to the conclusion that no set should be expected to operate very satisfactorily when the speaker is more than ten feet away. To compare hearing aids on the basis primarily of the distance at which they will function, as has sometimes been done, amounts to rating them only on a basis of amplification which is only one of several factors that affects their usefulness.

If a person of defective hearing is to select intelligently a set which will be best suited to him, he must have some simple method of comparison. There are so many types on the market that a selection without some definite criterion is generally a matter of very considerable difficulty.

Realizing this, our engineers

adapted methods for articulation testing and devised a method of comparison for all types of hearing aids. This was presented before the annual meeting of the American Federation of Leagues for the Hard of Hearing at their annual convention during the last week in June and was enthusiastically received.

Most of the large cities of the country have societies for the hard of hearing. At their various headquarters they ordinarily keep sample sets of the many types of hearing aids. Their members may then try the different ones in an effort to find something suitable. The selection is left to the user's judgment with no very good criterion to guide his decision. In the proposed method, however, his judgment is eliminated. Tests are made which indicate accurately the ability of the hearing aid to assist in the interpretation of speech. Also tests can be made which will indicate whether or not any type of hearing aid will be of real service.

In brief the test consists in determining the percentage of vowel and consonant sounds which may be interpreted correctly. Simple words, carefully chosen for the purpose, are pronounced very slowly, either with the hearing aid or directly with the ear. Such words as bat, bait, bet, bit, and bite are used which differ only in their vowel sound, or such as die, fie, guy, incorporating changes in their consonants. A list of one hundred suitable words has been made up composed of fifty monosyllables which differ only in their vowel sounds, and fifty differing only in their principal consonants.

VOWEL LIST

bat	bait	bet	beat	bit
bite	but	bought	boat	book
boot	bout	bat	bait	bet
beat	bit	bite	but	bought
boat	book	boot	bout	back
bake	back	beak	bit	bite
buck	balk	boat	book	boot
bout	back	bake	beck	beak
bit	bike	buck	balk	boat
book	boot	bout	bake	bike

CONSONANT LIST

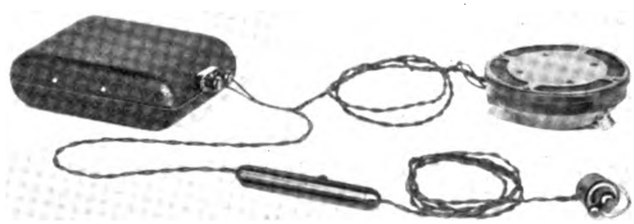
by	which	die	fie	guy
high	wick	lie	my	nigh
wing	pie	wry	sigh	shy
thy	thigh	tie	vie	why
wiz	by	which	die	fie
wig	high	wick	will	whim
win	wing	pie	wry	sigh
shy	thy	thigh	tie	vie
why	wiz	whiff	whip	sigh
wish	with	thigh	wit	vie

List of words used in testing the relative efficiency of hearing aids

This list is shown in the illustration. As only twelve vowel and twenty-one consonant sounds are used it is evident that there would have to be many repetitions of the same sound. The recommended procedure is to write each of the hundred words on a separate card. These may then be shuffled before each test so that the order in which they are given will be different each time, thereby eliminating any possibility of memory effecting the result. The words should be pronounced in a natural voice and at a fixed distance, preferably about three feet, from the hearing aid. Effort should be made to keep the speech volume constant. The rate of pronouncing them should be determined by the time required to write one word before the next one is pronounced.

A round total of fifty words each for the vowel and consonant lists was chosen so that the percentage heard correctly could readily be computed. In determining the vowel percentage only the vowel part of the word is considered. If 'bat' were pronounced and 'pat' recorded it would be rated correct since the vowel was correct. Similarly when considering consonants only the consonant part of the word is used for rating. Were "hay" recorded where "high" had been pronounced it would be marked correct as the significant consonant is the letter 'h.'

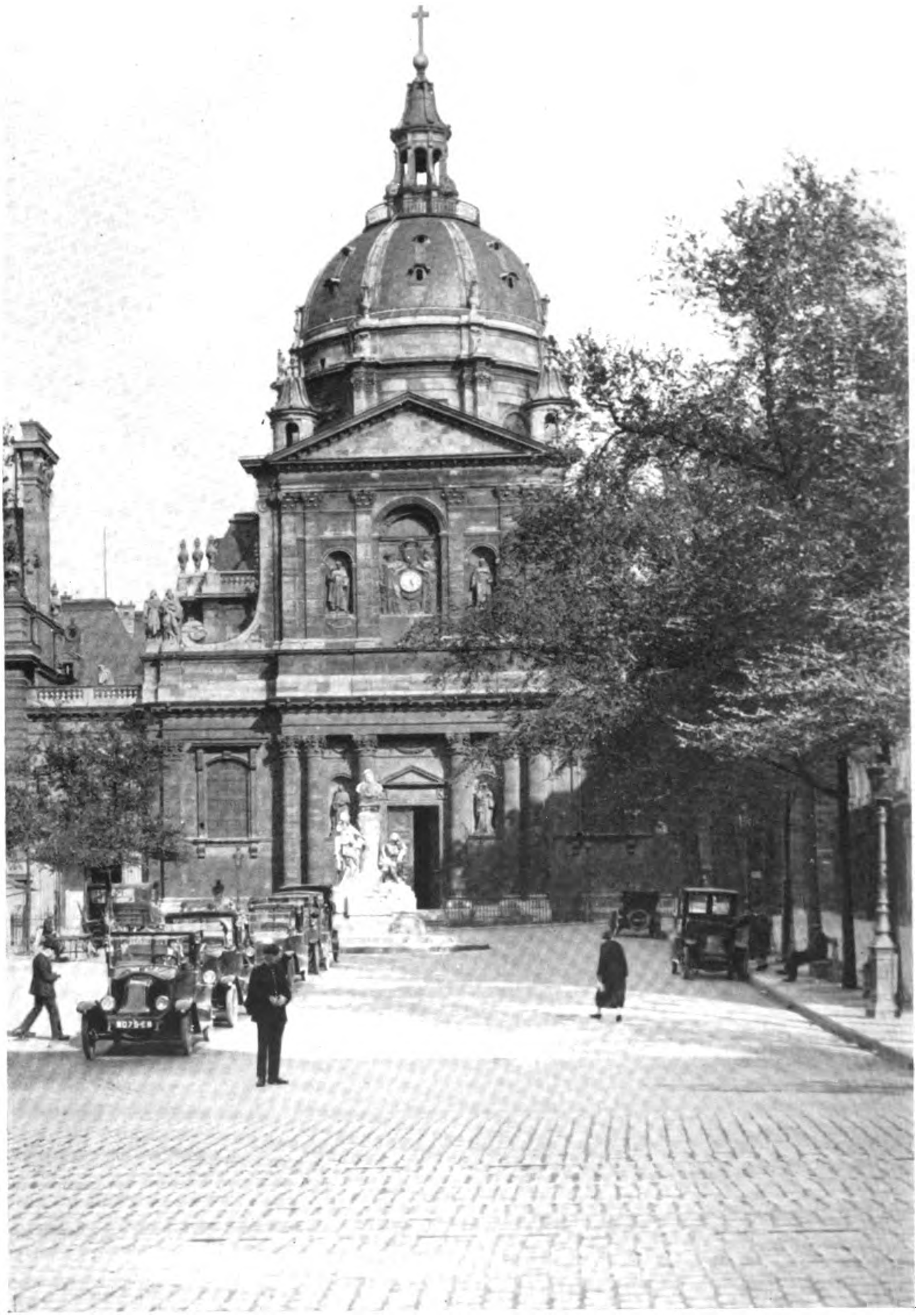
A merit figure, expressing for any individual the value to him of any particular hearing aid, is obtained by multiplying the percentage of vowel sounds he hears correctly by the percentage of correct consonant sounds and again by the percentage of correct consonant sounds. If 94% of the vowels had been right and



The 6033-B Audiophone is similar to the 6034-A, but the transmitter is hung on the coat-lapel and batteries are carried in the pocket

72% of the consonants the combined grade would be 49%. ($.94 \times .72 \times .72 = .49$). Consonants contribute more to intelligibility than do vowels which makes it necessary to give them more weight in the final rating. Much experimenting has been done to determine just how much more important the consonants are. The expression finally derived for the ratio is somewhat complicated, but is very closely approximated by using their percentage twice in the total product as was done above.

In the final selection of the hearing aid, two considerations must enter: first the ability of the set to aid in the interpretation of speech, and second its convenience as determined by such matters as its size, weight and ease of maintenance. Although the proposed method will give a definite measure of the first, the second can be judged only by the person who is actually using the set.



Church of the Sorbonne, University of Paris; one of the oldest of the University buildings

The Polarity of Learning

By J. S. HARTNETT
General Service Manager

IN the lounge of an Atlantic liner, a San Franciscan meets a man from Montreal. The camaraderie of shipboard leads to the finding that both have friends in Texas—the same friends. According to those who would classify our platitudes, here is merely another occasion for the repetition of that banal remark, "What a small place the world is, after all."

But a trite expression may clothe a glamourous thought. Relatively, the world is a small place. Recast this little scene; make its setting any one of our laboratories or any corridor of our building, and its time any day. Across our stage the Briton from South Africa walks regularly with the Dakotan, and the Carolinian rubs shoulders with the Dane. Their training in science, arts and law having brought these men together, we may in phrasing not entirely fanciful entitle our scene as I have entitled this article. For we are strikingly an organization drawn from world-wide places of learning and engaged reversely in pursuits which are eventually a reaching-out to the ends of the earth, making it aurally ever smaller, oblivious to distance. And thus in a sense even to effects of the planets—does not New York this morning give ear to London's voice of this afternoon?

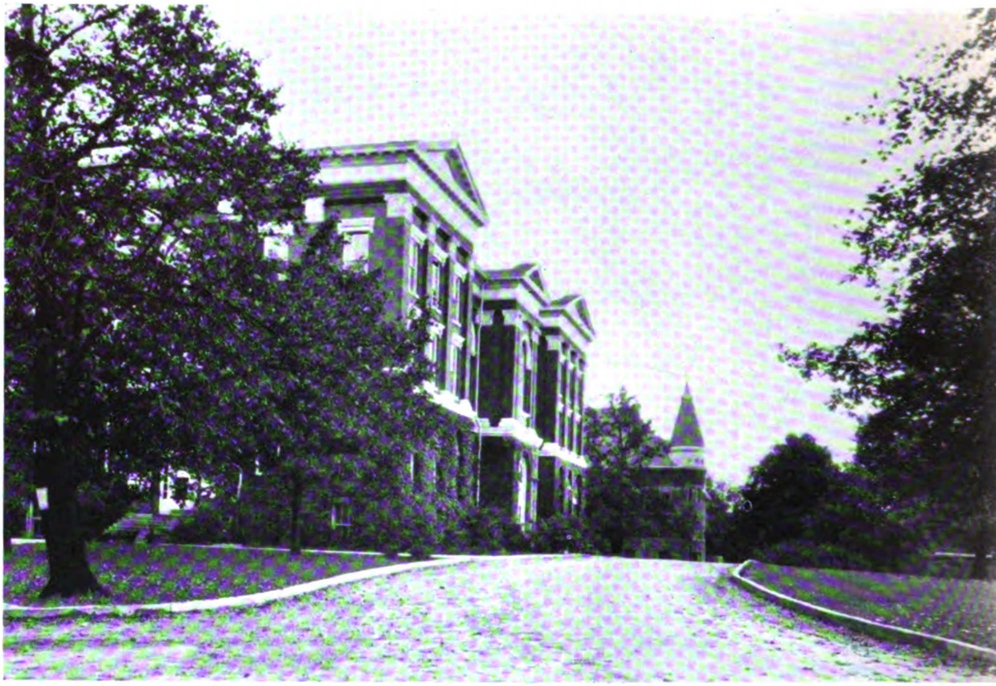
The personnel records of our organization outline well this tale of men and places. Reduced to a card form for each member of our staff and filed tightly in a cabinet drawer, they have all the dull aspect of their kind. None the less, they give imagination wing. Taking from these cards the colleges and universities from which our personnel is derived, we have indirectly the chapter-headings for a Baedeker or the sub-titles for a travelogue—and history galore.

Seeing America first, there are represented more than one hundred and fifty institutions of higher learning. Think of the name of almost any one of our States and then of any several others, either at random or in all of their possible alliterative cadence, and you will find in our ranks graduates from one or more colleges within the borders of each. "Believe it or not," a cartoonist says and then proceeds to add place or date to his pictures of striking facts. Appending my statements with similar data, incredulity becomes much less the alternative. The evidence is at our elbows in person.

'Way down East, for instance, in Maine are Bowdoin, Bates, Colby and the State University. In terms of a graduate respectively from each*, we have E. S. Pennell, L. B. Hilton, W. L. Dodge and S. H. Willard. Of these institutions the earliest in inception is Bowdoin. Deferred by the failure of John Hancock as Governor

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* *Graduates mentioned are either the earliest or the most recent to become members of the technical staff of the Laboratories.*



Administration Building, University of Kentucky

of Massachusetts, of which commonwealth Maine was then a district, to put his name to the covering act, its charter was eventually granted in 1794 and the college named for James Bowdoin, a former governor. Thirty years later it graduated Franklin Pierce, fourteenth President of the United States. In the following year, 1825, Hawthorne and Longfellow emerged from its doors, and in '77 the Peary who was to reach the Pole.

From across the continent, the University of California has representatives in M. B. Kerr and W. B. Warren. Thence also come W. B. Snow and B. R. Cole, graduates of the institution which Leland Stanford, capitalist, governor and senator, caused to be reared in the Santa Clara Valley in memory of his son. Stanford the elder dreamed magnificently. Today the university which he founded has enrollment of more than four thousand students and de Ballore, laureate of the Institut de France, gives it special mention in the Index Generalis as offering scientific training of the highest type. Occidental College, set down in the purlieus of Los Angeles, gives us R. G. Watling; the California Institute of Technology, A. R. Kemp; and Pomona, P. W. Stroud.

Ohio, Oklahoma, Oregon—to consider again widely separated states. Twelve institutions, within the first of these states alone, have graduated various members of our staff. From the University of Oklahoma, under patronage younger in statehood, are E. B. Ferrell and J. R. Reeves, now assigned to our radio stations on the Jersey coast. Oregon's University has alumni in F. E. Haworth and C. O. Wells, both of our Research Department. Mid-century, at Tuala-

tin Plains in this same state, Pacific University was founded, as were so many others, under clerical auspices; H. G. Romig, Inspection Engineering, is of its class of '21. And from the college in western Portland to which Simeon Reed and his wife, Massachusetts pioneers of 1854, left their name and fortune, we have R. M. Bozorth, Research also.

So on to increasing numbers and to references even epic goes the story of our personnel and the American sources of its training. In the very listing of the latter ring the echoes of the nation's history from its nascency. Institutions that bear names self-explaining: George Washington, Washington and Jefferson, Washington and Lee, Harvard, Yale, Cornell, John Marshall, Princeton, Gettysburg, Lafayette; those that are known for their technological standing: Massachusetts Institute, Chicago, Johns Hopkins, Stevens; founded by various sects: Notre Dame, Brigham Young, Trinity; the universities of our various states; and marking our modern cities: Pittsburg, Cincinnati, New York—all of these and others are represented. An anthology could be written but my space is in pages. There are yet other countries.

Northward, in the City of Saskatoon on the great plains of Canada, is the University of Saskatchewan. New, in a newly developing country, it began in 1907 to raise its buildings of native stone. Oxford stretched hands across the sea and granted it affiliation. To the opening of its hall of chemistry in 1924 came Baly of Liverpool and Irvine of St. Andrew's to present a discussion of the former's work in photosynthesis. Heri-



Washington and Lee University

tage it has; what may not vision do? On the staff of our Chemical Laboratory is E. J. Murphy, Saskatchewan '18.

Graduates of other and older Canadian learning are with us: from Toronto, J. L. Hogg; from McGill in Montreal, T. P. Neville. Across in New Brunswick, Mount Allison University, founded in 1862 at Sackville near Chignecto Bay, brings M. H. Lindsay; New Brunswick itself, J. O. McNally. From Acadia University, at Wolfville in Evangeline's country, Nova Scotia contributes.

Non-stop to France, to a university probably the oldest in the world: that of Paris. Vaguely set in the twelfth century, the date of its actual beginning remains unknown. A revival of interest in learning had come with the Crusades. The schools of the great cathedral towns were replacing the monasteries as seats of culture. Paris had recognizably, as we say today, the advantage of central location. The fame of Abelard, its great scholar, had gone afar. Thus tendencies converged towards an event and the year 1200 records the first chartering of the Paris University by royal grant of Philippe-Auguste. Relatively soon, questions of jurisdiction came up for hearing. A student foray, so ageless is instinct, had resulted in harm to the keeper of an inn. Lectures were suspended for two years. Then by papal bull of Gregory IX were established the controlling rights of the masters, some of which are even today in practice. Centuries later, the storm of the French Revolution checked the university's growth until on France and its institutions Napoleon laid reorganizing hand. Old though it is, the university is yet new enough to include in its curricula courses in radio-activity, aviation and optics. L. A. LeBaut of our Physical Laboratory comes from it.



Qu'Appelle Hall, University of Saskatchewan, Saskatoon, Canada

In our Patent Department, A. J.

Michel comes from another French university: Nancy, in the town of that name on the Meurthe. To Stanislas Leszczynski, dethroned as King of Poland in 1735 and appeased with the Duchies of Lorraine and Bar, the university owes much of its development and the town its beauty. The former dates its inception but four centuries after Paris. Its faculties had at first covered only theology and the arts. In 1582 law was added and later, letters and science. From Charles the Bold to von Hindenburg, wars of attrition have swept around Nancy. Yet in 1926 its university was providing tuition to more than two thousand students.

Of like early origin is the present-day University of Grenoble. Grenoble lies to the southeast of France, in a center noted for its development in hydro-electric engineering. Scenically its site is superb: to the north are the mountains of the Grande Chartreuse and within sight to the east, the Maritime Alps; through it runs the Isere. Significant of Grenoble's history, a series of fortresses rise high above the town. Strange admixture of his time, warrior and scholar, Francis I gave it impetus as a place of learning. A member of our Systems Development Department, R. A. Leconte, holds the university's degree of E.E.

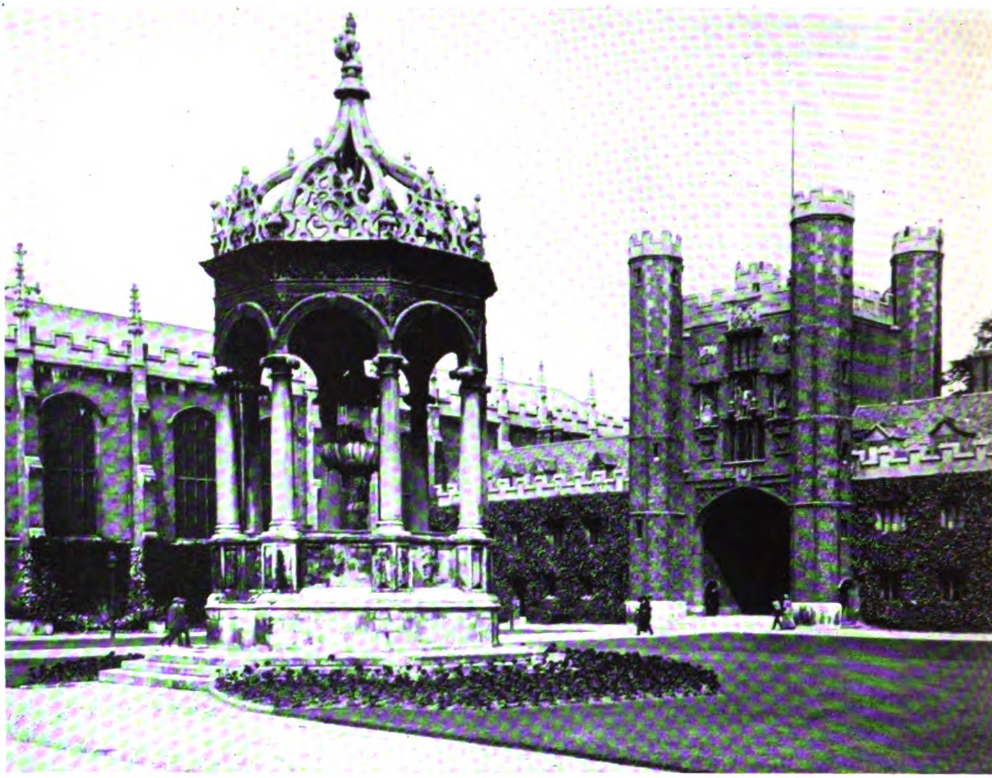
Elsewhere, too, in these earlier centuries, learning was beginning to stir. Continental upheavals were felt in England, despite the protecting seas. As in France, the mid-Crusades saw the first lighting of the torch. Before the flare was dimmed, Oxford and Cambridge had birth.

It was the nineteenth century, however, that marked the spread of the university college through the British



Students' Hostel, University of the Witwatersrand, Johannesburg, South Africa

Isles. Industrial development to the north, bringing population in its wake, made Oxford and Cambridge remote. So arose, under the sagacious if staid Victoria, the Universities of Liverpool, Manchester, Durham. At Newcastle-upon-Tyne, Armstrong College, a constituent of Durham, typifies this expansion. Brought into being in 1871 through the efforts of the North of England Institute of Mining and Mechanical Engineers, its first quarters were an upper floor in the Coal



Trinity Court and Gate, Cambridge University, Cambridge, England

Trade offices. In buildings covering city squares, widely technical training is now afforded. Its president is Grey of Fallodon. Armstrong graduated F. C. Willis, Apparatus Development; Manchester, the Wilsons, W. and R. H. At Oxford R. V. L. Hartley was a Rhodes Scholar coming from the University of Utah; L. E. Krohn, Research also, is from the University of London. From the National University of Ireland, constituted of Dublin College and Queen's at Cork and Galway, we have J. G. McIvor, Systems Development.

Across the North Sea to Delft in the Netherlands, around the Skagerrak and Kattegat to Copenhagen on the island of Zeeland, to Lund and Boras in Sweden, to Christiania nowadays Oslo—the technical institutes of all of these places are represented in our present personnel, although the beginnings of the institutions themselves are in instances dim in saga. So down the face of Europe to the ancient port of Genoa, claimant of Columbus—from a college of its university comes F. A. Bonomi, Manual Switching.

Thence to Asia Minor, the country east of the Aegean. In the military organization of the East Roman Empire, Anatolia was the name given to one of the three themes or provinces of Phrygia. Times much later, it signified a division of the Empire of the Turks. The currents of history back-wash strangely. Under a Massachusetts charter, the American Board of Foreign Missions established in 1886 at Marsovan, Turkey,

an institution to provide in that land advancement in learning—in name Anatolia College. The college followed naturally its American prototypes, drawing its faculty in part from Princeton, Williams, Iowa and Middlebury. Even this college is represented among us: by G. H. Paelian. An area turbulent for centuries, Anatolia is not yet quiet. With the World War came the closing of the college. It remains closed. The Turkish Republic is very young.

South Africa, to most of us, seems as far off as Cathay. About its university colleges we may not even have wondered. Yet there are among others those of Cape Town, Rhodes, Stellenbosch and the Witwatersrand. Outgrowth of the Kimberly Technical Institute and the South African School of Mines, the University of the Witwatersrand is located in Johannesburg, on a ridge a mile above the sea. Previously under Boer rule, Johannesburg was the center of the Uitlander agitation which marked the turn of the century and ended in the Transvaal War and occupation by the colonizing British. Thus does learning always expand with empire and the finding of rich fields of ore. It is a long route from the Transvaal to a building beside the Hudson. But we have on our chemical staff W. E. Campbell, Witwatersrand '23.

In one of the more brilliant passages of his classic treatise on the "Idea of a University," John Henry Newman inserts the terse conclusion: "It is a place to which a thousand schools make contribution." I borrow the sentence to describe our Laboratories.

A Compact Direct-Current Amplifier

By H. C. CURL
Apparatus Development Department

FOR some time there has been available to radio users an amplifier—the 6025-B—designed to form the last stage of a radio receiving system and to draw its power from a source of sixty-cycle alternating current. Only direct current is available in many parts of metropolitan areas, particularly in hotels and large apartment houses. Following the favorable reception given by the public to the 6025-B amplifier, the Laboratories took up the development of an amplifier of similar operating characteristics which should draw its power from a 115-volt direct-current circuit. The result is the 6031-A amplifier, now made by the Western Electric Company and sold by Graybar Electric Company.

Direct-current power supply simplified the design of this amplifier by removing the need for rectification, but at the same time it introduced a difficulty since it prevented the possibility of stepping up the available line voltage. It thereby restricted plate potential, and made it necessary for adequate power output to use a tube of low internal impedance. For that characteristic the 104-D tube was chosen; two of these tubes are used, connected in a push-pull circuit.

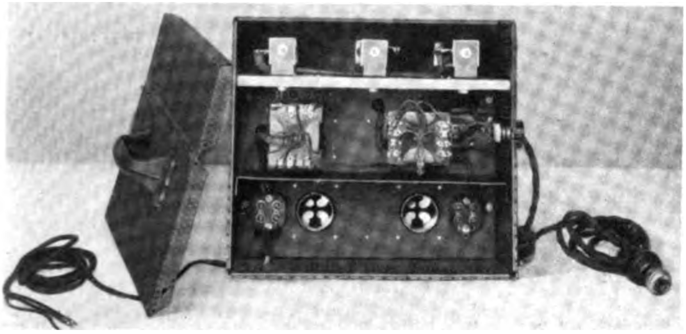
Current for the filaments, which are in series, is drawn from the direct-current line, being held to the proper value by series resistances. This current is one ampere, and represents power consumption of 115 watts. Since most of this power is dissipated in the resistances, they are of heat-resisting construction and are mounted on a panel of heat-insulating material. The box containing the apparatus is of perforated metal to provide ventilation and so to aid in keeping the temperature at a safe value.



The 6031-A amplifier is enclosed in a perforated steel box and is provided with cords for connection to the radio receiver and to the electric-lighting circuit

It will be noted from the circuit diagram that two of the series resistances R1 and R2 are connected at the positive side of the vacuum-tube filaments, and the other resistance R3 at the

negative side. The drop in voltage in this resistance provides a negative grid potential of about fifteen volts for one tube and twenty volts for the other. There is a like difference between the plate potentials of the

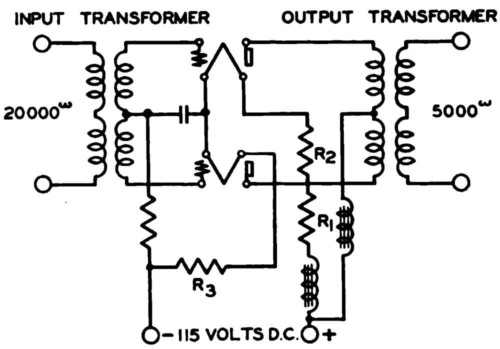


The amplifier as here shown (without tubes) is coded as the 31-*A Amplifier*

tubes, due to the voltage drop in the filament of the second tube. These unequal voltages on the grids and on the plates of the two push-pull tubes introduce an unbalance in the operating characteristics which could be avoided at the expense of some additional apparatus. For the 104-D vacuum tube, the value of grid voltage to give maximum power output is not so critical as it would be for a tube having a higher amplification factor, and the additional expense is not justified.

It has been pointed out that one of the limits of the output power obtainable from this amplifier is set by the plate potential available. This potential is not the full voltage of the power line, but is less than that value by the fall-of-potential across the resistance R3. Were negative bias on the grids to be secured from a "C" battery, the drop in R3 might have been added to the plate potential with an appreciable gain in the load-carrying capacity of the amplifier. A battery, however, in such an amplifier was objectionable from the standpoint of space and design requirements; a more serious objection was the inappropriateness of using a battery in a piece of apparatus intended to end maintenance and replacement cares.

Available power sources yield currents which although fairly smooth are not entirely free from voltage variations due to commutator ripple and to various other causes. As far as the plate circuit is concerned, these fluctuations are unimportant; acting in opposite directions through the primary winding of the output coil, they do not affect the secondary winding. A small amount of filtering is required for the filament and grid circuits; it



Circuit of the 6031-*A amplifier*

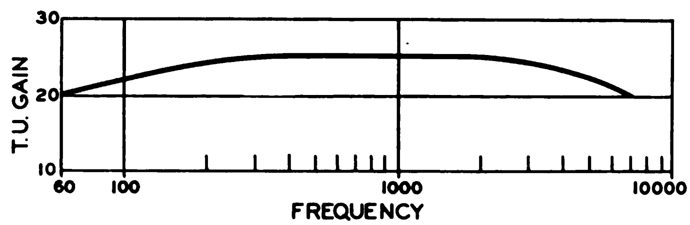
is provided by the retardation coil in the filament circuit and the resistance-and-condenser combination in the grid circuit.

The load-carrying capacity of the 6031-A amplifier is approximately thirteen transmission units above

zero level.* While this is about seven transmission units less than the load-carrying capacity of the 6025-B amplifier, it furnishes sufficient volume without appreciable distortion for the average living room when used in connection with a 540-AW loud-speaker. The amplification of the 6031-A amplifier is about twenty-five transmission units under usual operating conditions. This is about five transmission units less than the amplification of the 6025-B amplifier. Considering, however, the difference in output capacity, it will be seen that at full load each amplifier requires about the same input level. The 6031-A amplifier, like the 6025-B, is designed to be operated from a radio receiver having one stage of audio-frequency amplification after the detector. No volume-control is provided, as this adjustment can readily be made in the radio-receiver circuit.

* *Zero level has been assumed as .006 watt.*

One point which might be forgotten when using this amplifier is that the attachment plug must be connected to the house lighting circuit with the proper polarity. If the negative side of the house lighting circuit is connected to the positive power terminal of the amplifier, the tubes will light but nothing will be heard in the output of the amplifier, since the plates will be negative to the filament.



Characteristic performance-curve of the 6031-A amplifier

A Practical Short-Wave Oscillator

By C. R. ENGLUND
Research Department

SHORT waves, by which is meant waves under one hundred meters and corresponding to frequencies of over three million cycles per second, have been attracting more and more interest and attention during recent years. The time seemed opportune, therefore, for an investigation of the short-wave-length limit of vacuum-tube oscillators, the only known generators of continuous trains of such waves. As considerable work had already been done by others the purpose here was to pick up and carry on the threads of past researches with the hope of more definitely settling the question. During the past year, therefore, work has been carried on which has not only attained its objectives by determining the limitations of vacuum-tube oscillators, but has actually demonstrated the sending and receiving of waves of three and one-half to four meters over distances of one mile.

In the production of very high frequency oscillations two distinct difficulties arise. These may perhaps be better appreciated by a consideration of a mechanical analogy. Picture for example a short section of a roller coaster such as is shown in Figure 1. The car C starting from the point A would roll down the slope pulled by gravity and then due to momentum it had acquired would rise up the opposite slope toward B. Because of the frictional losses of the car, however, it would not quite reach B. But let us assume that some means has been found to give it the push needed to bring the car up to the level from which it started. With only this slight periodical addition of energy the car will now oscillate back and forth indefinitely. This push applied at the proper time corresponds to the action of the vacuum tube oscillator in an electrical circuit.

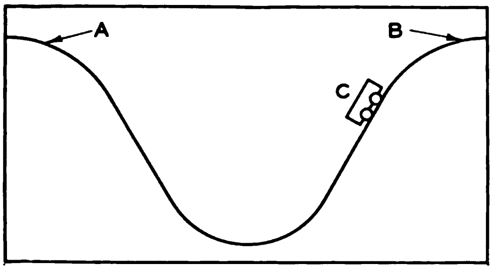
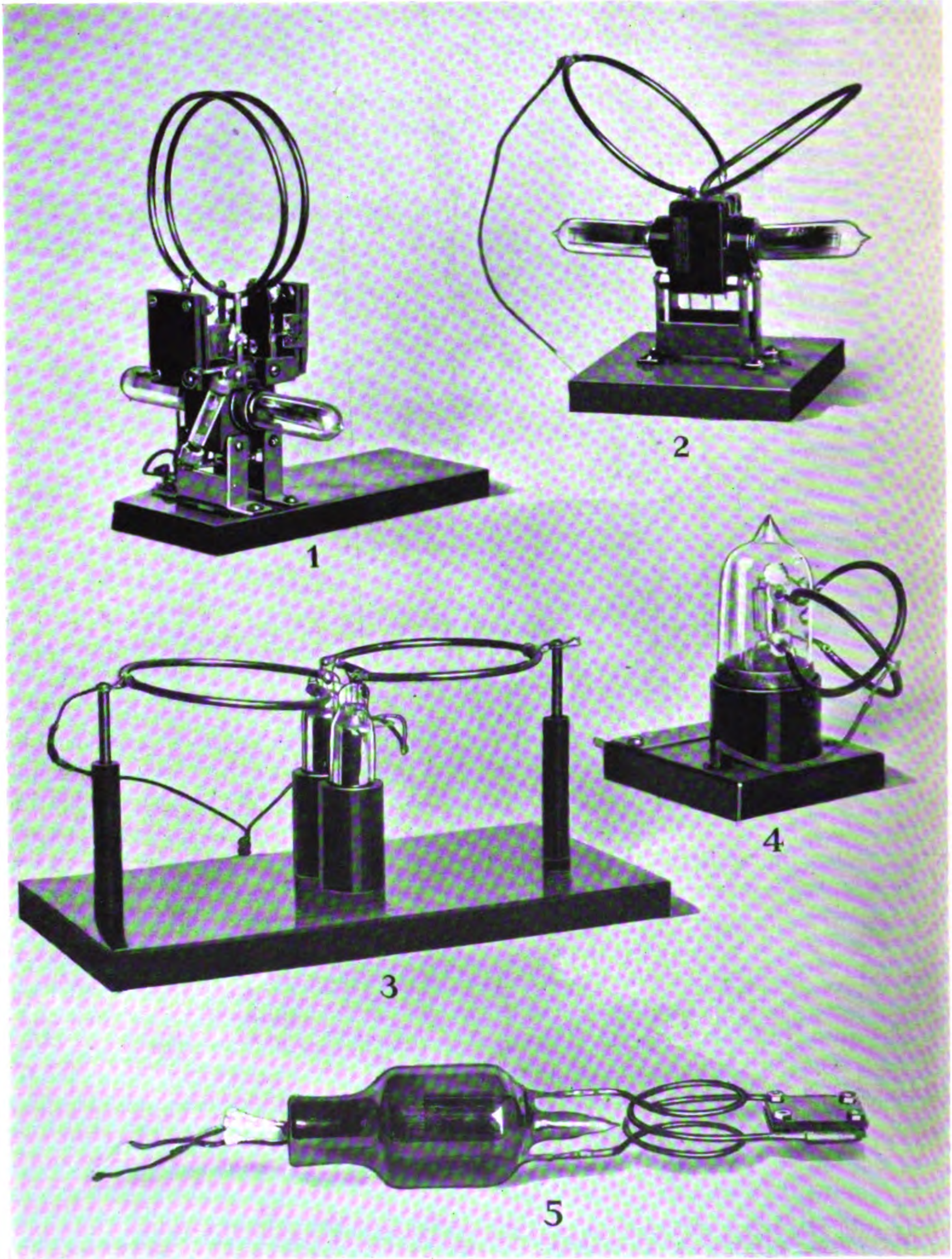


Figure 1

The time for one complete oscillation of the ordinary roller coaster would be relatively long. To shorten it the track would have to be made steeper and shorter. In doing this, however, the point is soon reached when it becomes impossible to make the track shorter and have room for any sort of car. In other words, there is a certain, but more or less indefinite, limit below which the time of oscillation can not be shortened. The limitation in this case is due to the fixed value of the gravitational constant "g" which directly determines the acceleration of the car



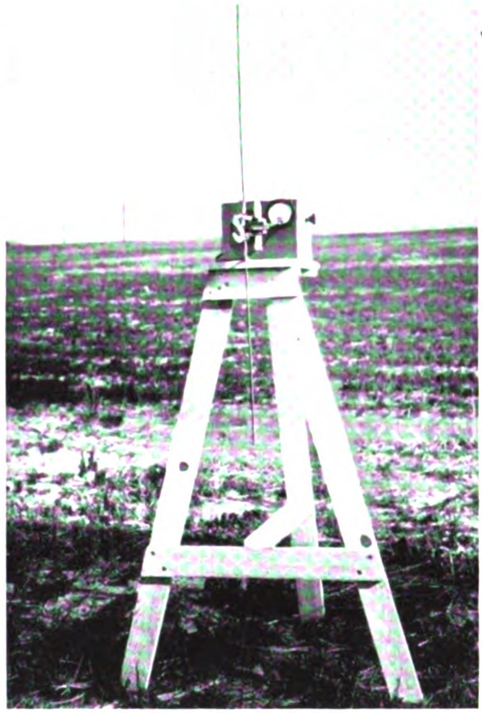
The metamorphosis of the short-wave oscillator. Figures show its development from a two-tube push-pull outfit to a single tube with two sets of electrodes

down the slope, and to the size restrictions, structural features if you will, of materials and tools.

Turning back now to the radio waves, similar factors also limit the rapidity of oscillations. These are the size of the equipment used to obtain the oscillations—in particular the magnitude of the inductance and capacity. For as the car of the roller coaster coasts down one side of the slope and up the other, so the energy of the electric current oscillates back and forth from inductance to capacity in its resonant circuit. The smaller the inductance and capacity, the more rapid will be the oscillations. Here lies the difficulty, however, for capacities and inductances can not be reduced indefinitely. Just a straight piece of wire has an inductance—small but of appreciable amount, and between the tube electrodes there also exists a capacitance. Thus in the effort to get oscillations of greater and greater frequency the point is reached when the capacitance and inductance are reduced to merely that between the tube electrodes and in the necessary connecting leads.



Transmitter



Receiver

It was found that the shortest wave lengths could be obtained by using two tubes with a push-pull type of circuit. The progress of the search for shorter and shorter waves is well indicated by the accompanying illustrations. Blazed on the one hand by simplification of the circuit and on the

other by shortening of the connections, the trail led past the use of unbased tubes to the placing of two tube elements in one bulb. This arrangement finally obtained a wave of 1.05 meters but the price was the loss of adjustment. Without this, practical reception would be difficult, and to regain adjustability it was necessary to return to two meters.

When an effort at heterodyne reception on this wave length was made, however, another serious difficulty developed. Two meters correspond to a frequency of 150,000,000 cycles. To get a one thousand cycle beat for heterodyne reception, a heterodyning wave differing from this by only a thousand cycles is required. This means that the frequency of oscillation must be held to one part in 150,000, a degree of stability impossible to secure with the relatively simple circuits used. As the heterodyne frequency passed through the audible beat range only a hiss was heard. To be able to heterodyne the received wave satisfactorily without adding expensive circuit complications, it was necessary to go above three meters which was stepping back into the region where a single tube was feasible.

It was found possible to obtain a normal power output, with frequency control and without departing greatly from standard vacuum tube construction, at 3.7 meters. This was a single-tube oscillator and was used, as the illustrations show, for radio transmission over short distances. With a double-tube connection and an improved design of tubes there is no doubt that this can be carried to three meters. This wave length corresponds to a frequency one hundred times greater than the normal radio broadcast band and may be taken as the present practical limit.

The System's Newest Associated Company

The New Jersey Bell Telephone Company, which begins its career October first, has been formed by combining the New Jersey properties of the New York Telephone Company and the Delaware and Atlantic Telegraph and Telephone Company. It serves approximately 572,000 telephones. Chester I. Barnard is President with G. W. McRae, Vice-President and General Manager; Frankland Briggs, Vice-President and General Counsel; C. F. Brisbin, Vice-President in charge of Public Relations and Personnel; S. C. Ormsbee, Secretary and Treasurer and H. A. Trax, General Auditor.

Headquarters of the new organization are at 1060 Broad Street, Newark, while a new twenty-story building to house the Company's administrative offices is under construction.

Sheet Insulating Materials

By J. M. WILSON

TO terminate ten thousand telephone lines within convenient reach of an operator has taxed the ingenuity of the designers of telephone apparatus. In the multiple of a "B" switchboard—a space five feet wide and two and a half feet high—are thirty-one thousand contacts, each insulated from the others. This achievement is possible only by the most judicious use of the space available; it has been accomplished by making the jacks as compact as is commercially possible. In the development of this and other apparatus a careful study has been made of the sheet material which insulates the current-carrying parts.

Of the properties of insulators, the most important in telephone work is electrical leakage across and through the material. This is in contrast to the requirements in power work, where dielectric strength is generally the determining factor and where the material must not sustain an arc should flash-over occur. The reason for this contrast is that telephone apparatus is operated at low voltages, and by relatively feeble currents whose loss through leakage must be reduced as far as possible.

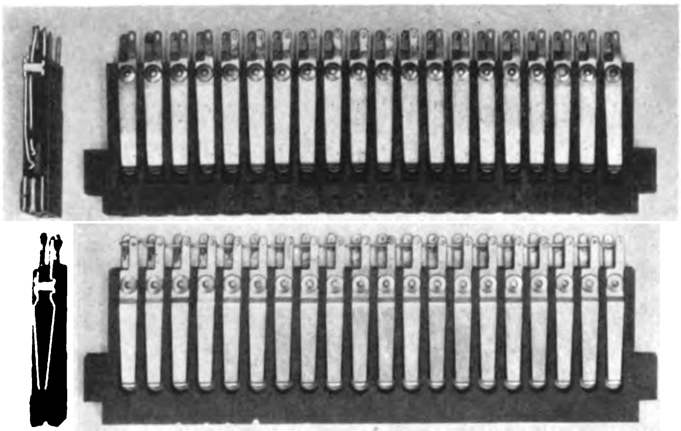
Broadly, an insulating material is one which does not conduct electric current. This, of course, is true only in the case of an ideal insulator. For telephone engineering, it is more accurate to consider an insulator as being a very inefficient conductor but a conductor nevertheless. It follows that if we inquire as to the resistance of an insulating material, we are doing nothing more than determining whether or not the resistance is sufficiently high to prevent current leakage of an objectionable amount. Further, we will find that this resistance is decidedly variable, depending largely on the atmospheric conditions to which the material has been exposed, not only at the time of the test but also during some hours preceding the test.

The insulation resistance of all materials drops rapidly during humid weather, in most cases to a small fraction of its original value when dry. Because of this only those materials which are least affected by humidity can be considered for application in telephone apparatus, where there are in every circuit a great number of parallel leakage paths.

The three insulating materials most widely used in sheet form for the construction of telephone apparatus are hard rubber, phenol fibre, and vulcanized fibre. Other materials such as mica, micanite and varnished fabric are used to some extent.

Hard rubber, as everyone knows, is an excellent insulator. It can be made in various grades. Of these some are suitable for difficult machining operations such as in the strip mountings for jacks and lamp sockets; others are suitable for spring assembles, graphically known as "pileups." Hard

rubber is, however, not without some objectionable qualities. Spring assemblies using insulators of hard rubber are difficult to keep tight, and repeated tightening of the mounting screws avails but temporarily. Unless the clamping areas are relatively large, so that the unit pressure on the insulators is low, the hard rubber gradually flows from under the clamping surfaces, resulting in loosening of the assembly. This yielding is commonly called "cold flow"; and as the term implies, the hard rubber behaves not unlike an extremely viscuous liquid. Cold flow takes place at ordinary temperatures, but becomes very noticeable above one hundred degrees Fahrenheit—a temperature which may be encountered in telephone service.



Hard Rubber Mounting Strips for Jacks and Lamp Sockets

Another very noticeable limitation to the use of hard rubber is its marked deterioration when exposed to light. This deterioration progresses at a rate depending upon the nature and the strength of the light, and therefore strong sunlight is particularly harmful. The effect is studied in the laboratory by exposing the specimens to direct sunlight; the result, however, can be very closely duplicated by exposing the samples to ultra-violet rays. This deterioration appears to be mostly on the surface but it results in a decided lowering of resistance when the rubber is subsequently subjected to the higher humidities. It is accompanied by discoloration, in which the exposed surface turns greenish-yellow.

These two objections to the use of hard rubber, particularly its tendency to cold flow, led many years ago to an extensive search for better materials. Of those studied, phenol fibre proved to be the most satisfactory substitute, and its use has increased since it was first employed in telephone apparatus about thirteen years ago.

Phenol fibre is a laminated product made in convenient thicknesses from sheets of paper treated with a varnish made from phenol and formaldehyde. The treated sheets are stacked to the desired thicknesses and cured into a solid mass by heat and pressure. A number of phenol fibres are marketed under trade names, such as Bakelite-Dilecto, Formica, Micarta, Condensite Celoron, Bakelite-Duresto and Phenolite. The varnish used in the manufacture of all these products is obtained from the Bakelite Corporation of America. Many of the commercial products of this type have been investigated in the laboratory and a number have been approved for use in telephone apparatus.

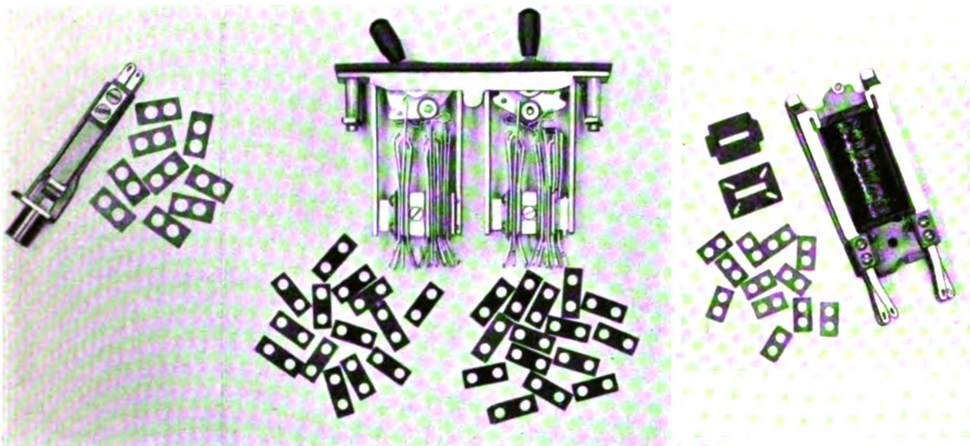
Two kinds of phenol fibre are used by the Manufacturing Department of

the Western Electric Company. Grade 1, generally used for spring assemblies, has the greater varnish content. This results in a more costly material than Grade 2, but one of somewhat better electrical properties. However, it is slightly more brittle and does not withstand most machining operations as well. The higher varnish content of Grade 1 is due largely to the use of cotton-fibre paper which is more absorbant than the wood-pulp paper used in Grade 2. It is very difficult for the unaided eye to distinguish material of one grade from the other. This was a source of confusion in the stock-room until the scheme was adopted of making up all Grade 2 material with a brown body and black surface, and making all Grade 1 material of solid color throughout, either brown or black.

The insulation resistance of Grade 1 phenol fibre is not as high as that of hard rubber when both are new. Due to deterioration, however, hard rubber soon loses this advantage; while the phenol fibre stands up so well that after a short time its insulation resistance is generally the higher.

Cold flow is practically absent in phenol fibre; it is this fact which has had most to do with its wide application as a substitute for hard rubber. The very slight change in dimensions which does occur is essentially a shrinkage due to the drying out of the material and the loss of gaseous products. For all but the most exacting uses this shrinkage can be considered negligible with Grade 1 material. In Grade 2, shrinkage is more pronounced and for that reason this material cannot be depended upon to maintain delicate adjustments.

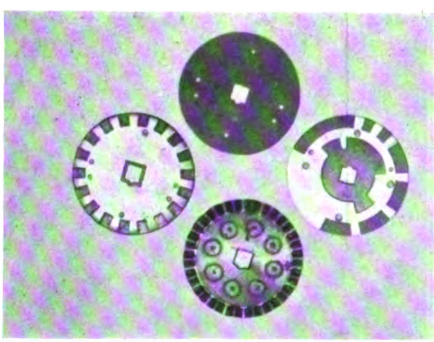
Neither grade of phenol fibre is as readily machined as is hard rubber. Before punch operations it is generally necessary to heat phenol fibre to reduce objectionable brittleness. Drilling and milling operations can be carried out with little difficulty, if they are done in a direction perpendicular to the laminations, otherwise there is a marked tendency for the



Phenol Fibre Punchings for Spring Assemblies and Spool Heads

material to split. Considerable gain in strength and toughness can be obtained by using phenol fabric, a more expensive material with a base of cloth instead of paper. As would be expected it withstands punching better than phenol fibre.

Vulcanized fibre — also known as "ordinary" fibre, "horn" fibre, and "hard" fibre—is used in large quantities. The term "vulcanized" is a misnomer, since heat and sulphur are not used in its manufacture as in the preparation of hard rubber, nor is it cured by heat and pressure as is phenol fibre. Instead, it is made from a rag-stock paper which has been treated with zinc chloride to soften



Sequence Switch Cam Assemblies Using Phenol Fibre Insulators

the cellulose fibres. This facilitates the matting of the fibres when the treated paper is wound on a drum. After a sufficient amount has been rolled up to give the desired thickness the wrapping is cut from the drum and flattened into a sheet. When the chemical action has been carried to the desired extent the sheet undergoes a series of washings in water to remove as much of the zinc chloride as possible. After being thoroughly air-dried the sheet is rolled and pressed. This operation toughens the fibre and improves its surface. Vulcanized fibre is generally produced in one of three colors, natural (gray), red or black. The latter colors are obtained by the addition of dyes to the zinc-chloride solution.

The outstanding characteristics of vulcanized fibre which have resulted in its wide use are toughness, adaptability to machine processes, and low cost. Its strength and toughness make it the most desirable insulating material for conditions of severe wear and mechanical abuse.

Unfortunately, there are many places where vulcanized fibre cannot be used owing to its tendency to cause corrosion of current-carrying parts. This is the result of electrolytic action involving the traces* of zinc chloride which remain in the fibre. In the past we have investigated a number of so-called non-corrosive vulcanized fibres. Although great care had been used to reduce the residue of zinc chloride to a minimum it appears to be commercially impossible to eliminate the last trace, and only a trace is necessary to restrict greatly the use of this material. Suffice it to say, that we are still looking for a vulcanized fibre which will be truly non-corrosive.

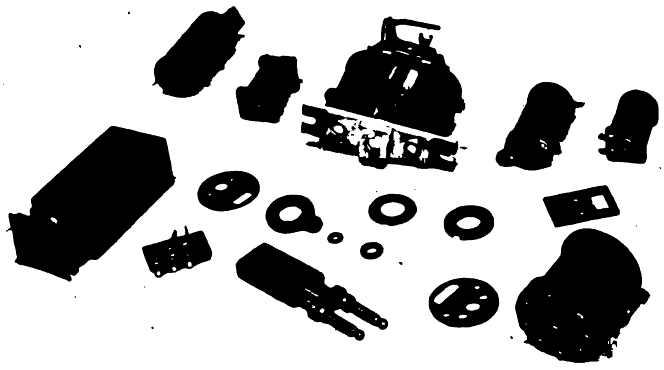


Plug Shell Machined from Sheet Phenol Fibre

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* *By specification the chlorine content is limited to a maximum of one-tenth of one per cent.*

Another serious objection to the use of vulcanized fibre is that, under high humidity, considerable swelling and warping occur. Impregnation and surface finishes help, but generally their protection is limited to those apparatus parts where ample allowance for dimensional changes may be made. As would be expected with a material having so marked an affinity for moisture, its insulation is so low under adverse weather conditions, that it is generally considered unsatisfactory for insulating terminals in talking circuits.



Sheet Vulcanized Fibre Parts, All Punchings Except the Plug Shell

Each year a large number of new insulating materials are investigated in our General Development Laboratory. Some are brought to our attention by inventors, others by promoters and of a few we first learn in the technical magazines. In spite of the most glowing promises by their backers such materials rarely prove satisfactory for use in telephone apparatus. Frequently the original samples look interesting; when we call for further samples, we sometimes find that the favorable showing in the early tests was pure "beginner's luck." Being made under uncontrolled conditions—in a boarding-house kitchen, for example, or in a hall bedroom—the first sample of the material cannot be duplicated.

No matter what its source, every proposed material is carefully considered since it may prove suitable for some special purpose, if not for widest application. In the investigation of these materials, as many short-cuts are taken as possible. Experience for example has shown that most new materials fail to meet our exacting requirements for insulation resistance; consequently the work is greatly shortened by determining first the insulation resistance of a new material under adverse atmospheric conditions. If these preliminary tests show promise the investigation is then broadened to include other properties, both electrical and mechanical. Due consideration is also given to the material's suitability to established methods of manufacture, to its cost, and to the reliability of its sources of supply. It would be difficult if not impossible to assign to all these properties numerical values which must be attained by a new material before it could be rated as suitable. As an alternative, our practice is to determine how each new material compares with the existing material for which it is a proposed substitute. In this comparison particular attention is paid to properties in which improvement is desirable, so that the changes recommended will be in the direction of better materials for the plant of the Bell System.

News of the Month

AMONG RECENT ACCESSIONS to the Historical Museum are two samples of telephone cable made before the present paper-insulated lead-covered cable was introduced. One sample is a cable of cotton-insulated wires, rosin-oil filled, with a tinfoil cover and wrapped on the outside with jute. This cable was installed in Chestnut Street, Philadelphia, in 1886. The other sample is a cable with cotton-insulated wires, rosin-oil filled, and lead covered; it includes the first splice made in a lead-covered cable in the city of Philadelphia, 1889. These samples were presented to the Historical Museum by James Cunningham of the Bell Telephone Company of Pennsylvania.

* * *

S. P. GRACE addressed the fifth annual convention of the Telephone Association of New Hampshire at Laconia, New Hampshire, on September 8. He told of the work of the Laboratories, and accompanied his address with a demonstration of an audiometer and with records of speech and music, natural, inverted and filtered. On September 13 he spoke again on the Laboratories and its work, to the Maine State Telephone Association at Portland, Maine, and gave the demonstration also. At both meetings Mr. Grace showed the film, "The Magic of Communication."

On August 22 Mr. Grace addressed the Business Men's Association at Jamestown, New York, on telephone and other recent developments of the Laboratories. The manufacturers present, many of whom have laboratories in their own establishments, showed the keenest interest in our work.

RESEARCH

E. E. SCHUMACHER recently spent a few days at Hawthorne in connection with the development of cable sheathing.

F. G. BRICKWEDDE, in charge of low temperature work at the Bureau of Standards, visited the Laboratories on August twenty-third.

H. H. LOWRY, E. E. SCHUMACHER, A. C. WALKER, J. A. LEE and A. N. GRAY attended a meeting of the American Chemical Society held at Detroit from September 6th to 9th.

R. E. WATERMAN and C. O. WELLS of the Research Department and C. H. Amadon and L. V. Lodge of the Outside Plant Development Department recently returned from a month's stay at Brookline, Mass., where they were interested in wood preservation experiments.

F. F. FARNSWORTH, E. E. SCHUMACHER and J. H. WHITE attended the Convention of the American Society for Steel Treating held at Detroit in September.

DURING THE WEEK OF SEPTEMBER TWELFTH several groups from the Chemical Laboratories were at Hawthorne in connection with different phases of their work. R. R. Williams, A. R. Kemp, J. A. Lee, and A. N. Gray were interested in sub-

marine cable and rubber covered wire, F. F. Farnsworth and J. T. Acker in aluminum diaphragms, and Messrs. Williams and Farnsworth in enameled wire.

A. A. CLOKEY returned to the Laboratories on September first from a three months' trip abroad. His work on the New York-Azores-Emden cable took him to Emden, Berlin and Horta. He also visited London and Penzance in connection with proposed apparatus for the New York-Bay Roberts-Penzance cable.

INSPECTION

DURING OCTOBER H. G. Eddy, W. C. Miller, R. M. Moody and P. S. Olmstead were in attendance at Inspection Survey Conferences held at Hawthorne.

W. A. SHEWHART attended the Colloquium Lectures of the American Mathematical Society and the joint meetings of the American Mathematical Society and the American Mathematical Association, which were held at Madison, Wisconsin, during the week of September 5. On September 7, he delivered an illustrated lecture on "Some Modern Developments in the Method of Analyzing Scientific and Engineering Data." Mr. Shewhart visited at the University of Illinois, conferring with various people who were interested in the theory of sampling. While there, he gave a paper before the Mathematics and Physics Colloquium upon the subject he discussed at Madison.

D. A. QUARLES and H. F. DODGE were in attendance at a Conference on Quality Rating of Manufactured Product held at Hawthorne during the week of August 22.

DURING the week of September 5, J. A. St. Clair, Local Field Engineer for the Inspection Department at Atlanta, was in Gulfport, Mississippi, and New Orleans, Louisiana, on complaint investigation work in his territory.

E. F. HELBING was at the factory of the Buffalo Gasoline Motor Company at Buffalo in connection with the new type "R" gasoline engine.

P. B. ALMQUIST, Local Field Engineer at San Francisco, was in Portland, Seattle, and Spokane recently in connection with regular field work in his territory.

E. G. D. PATERSON visited the factory of the Corning Glass Company at Corning, New York, to investigate manufacturing processes on glass insulators.

OUTSIDE PLANT DEVELOPMENT

E. M. HONAN was in New Haven with engineers of the American Telephone and Telegraph Company and of the Southern New England Telephone Company, making experimental installations of attachments for drop wire.

C. D. HOCKER and W. A. HYDE visited Schenectady and Pittsburgh to study metal corrosion and glass insulator problems. Mr. Hyde was also in Muncie, Indiana, during August in connection with glass insulator development work.

L. V. LODGE was in Brookline, Massachusetts, conducting timber preservation experiments.

S. C. MILLER visited Madison and Minneapolis in connection with timber development studies.

C. S. GORDON and B. A. MERRICK were in Roslyn, Long Island, making tests of devices for splicing cable under tension. Mr. Gordon was in Philadelphia later, conducting field experiments with drop wire attachments.

Systems Development

W. L. Dodge spent several days at Boston on an investigation of sender operation in panel dial offices.

P. T. Slattery visited Scranton, in connection with the installation of repeater equipment.

R. H. Kreider spent a week at Hawthorne making arrangements for the manufacture of equipment intended for use in field trials of new developments in step-by-step P. B. X. design.

Various angles relating to the substitution of ebony-asbestos compound for slate in power boards were discussed with the General Electric Company's engineers by R. L. Lunsford and F. T. Forster during a recent visit to Schenectady. At the same time the new Schenectady step-by-step dial equipment was inspected in connection with a study of the application of the new aluminum finishes to power-room equipment.

The 551-A and 551-B P.B.X. equipments have replaced the 550-C equipments and V. I. Cruser is visiting Hawthorne to assist in connection with the new manufacturing program now under way.

W. F. Malone visited Pittsburgh, Ligonier, Bedford and Harrisburg, Pennsylvania, to inspect special equipment being installed for use in studies of broadcasting over cable pairs between New York and Pittsburgh. F. S. Entz, A. E. Bachelet and R. A. Leconte have also spent several days at the Philadelphia Instrument Shop and at Pittsburgh and other Pennsylvania points making tests on this equipment.

E. P. Bancroft and C. E. White spent several weeks in San Francisco and Chicago, respectively, testing experimental installations of constant-frequency current-supply sets which are being tried out with picture-transmission systems as a replacing medium for the synchronizing channels now in use.

R. B. Steele has recently been conducting tests at El Paso, Texas, on a trial installation of static interference suppressor equipment on carrier-telegraph lines between Denver and El Paso.

Apparatus Development

L. B. Cooke is at Minneapolis, Minn., modifying the power line carrier telephone system of the Northern States Power Company.

E. Montchyk and J. T. Butterfield were in Boston early in August to investigate field tests of 1-A bearings.

H. S. Smith was at Hawthorne the middle of August and early in September in connection with the development of a special tinsel cord for step-by-step switches.

H. R. Kimball spent some time at Hawthorne installing and testing a test set for measuring the reflection coefficient on single channel carrier systems.

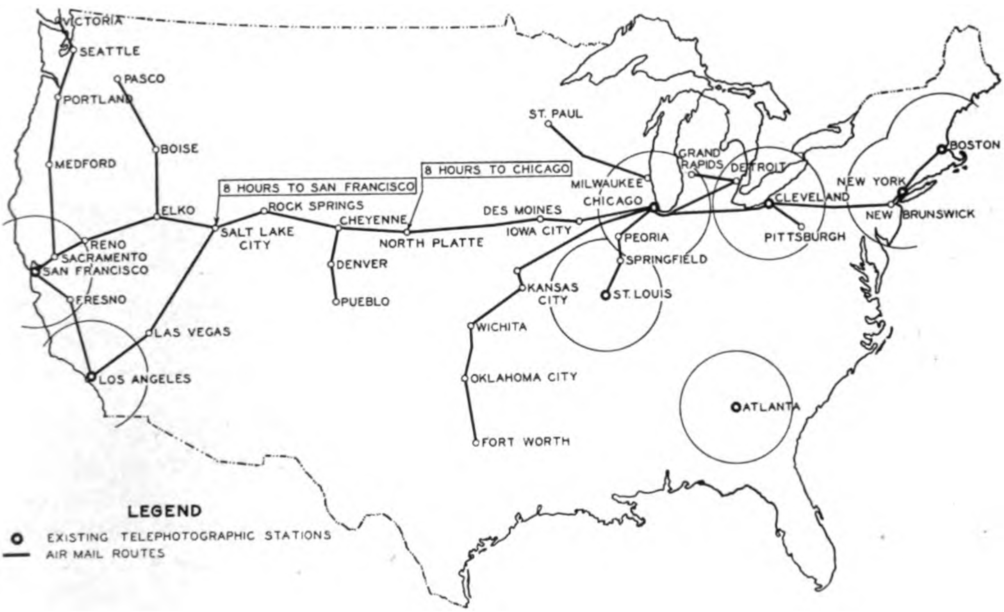
R. S. Bair, J. W. Grieg, R. E. Poole and H. S. Price have been directing various stages of the preparation of Station WOR, which is to be key station of the Columbia Broadcasting System. A five kilowatt transmitter has been installed near Kearney, and the studios in New York are being provided with equipment developed in the Laboratories for speech input control.

W. L. Tierney went recently to Shenandoah, Iowa, and H. S. Price to St. Louis and to Fort Worth, Texas, for consultation with broadcasters. Control exercised by the Federal Radio Commission has brought

many requests for assistance of the field engineers in instructing staffs and suggesting improvements in equipment and operation procedure.

W. V. Wolfe went to Barberton, Ohio, early in September to inspect the new condensers to be used on the power line carrier telephone installation for the Pacific Gas and Electric Company.

James A. Wotton, for many years a member of the Apparatus Development Department, died on August twenty-second after a short illness. Since his graduation in 1884 from the University of Georgia, Mr. Wotton had spent practically all of his active career in the telephone industry, to which he made important contributions. For some years he was Chief Electrician of the Southern Bell Telephone and Telegraph Company.

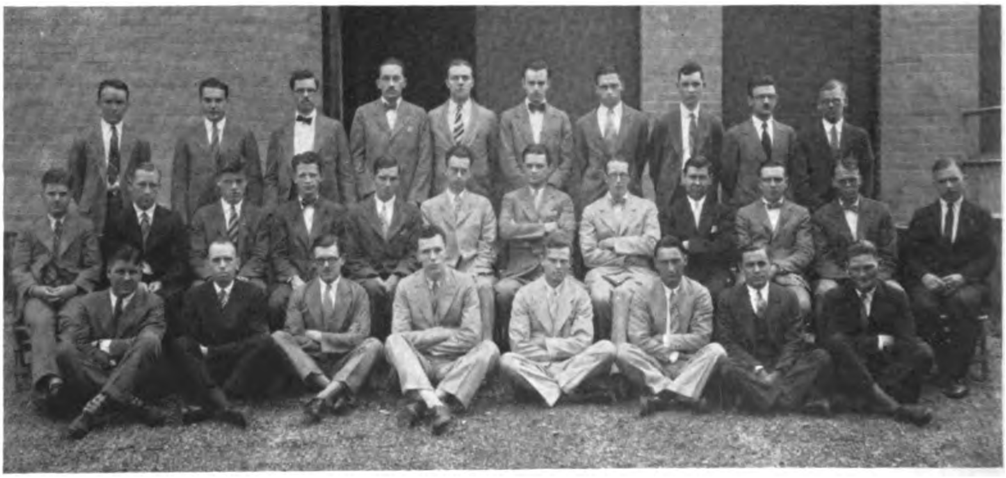


How the telephotograph system has drawn this country together is visualized by this map. The larger circles represent roughly eight hours by train from the nearest telephotographic station. A picture originating in any of these areas can within a few hours be in the hands of newspapers in eight cities. Air mail still further increases the areas served by the telephotographic system

Introducing the New College Men

TODAY the Bell System stands in the front rank of American industrial organizations. The criteria of size—stockholders, capital, personnel—accord it preeminence. Its bigness together with its geographical extent have caused the responsibilities for carrying it on to be divided not only among many departments but among many distinct companies. These considerations together with the unusually technical art upon which it is founded make it often seem to new members that the business they have entered is extremely complex. As a matter of fact the reverse is actually the case.

To help over any initial difficulties for those coming from the colleges and elsewhere, and affiliating themselves with the Laboratories, it is customary for our Educational Department to offer a brief but intensive introductory course. During this instruction, the newcomers have explained to them the organization of



Top Row: *S. T. Meyers, Stevens Institute; E. R. LeRoy, M. I. T.; P. C. Jones, M. I. T.; J. W. Obreiter, Brooklyn Poly.; E. J. Thielen, U. of Cincinnati; F. D. Kurie, McGill U., Montreal; F. J. Grignon, Cornell; W. F. Schoening, Washington U.; W. C. Parnell, Queens U., Kingston, Canada; G. C. Engel, Stevens Inst. Middle Row: C. G. Scofield, McGill U.; H. J. Scott, U. of Wash.; T. G. Fischer, Johns Hopkins; H. P. Smith, U. of Kansas; E. L. Alford, U. of Mo.; E. S. Willis, U. of Mo.; H. N. Walker, Brooklyn Poly.; R. C. Shaw, U. of Mich.; W. C. Slauson, Hamilton College; C. E. Fay, Washington U.; P. W. Wadsworth, Ohio Northern; A. L. Bonner, U. of Minn. Bottom Row: H. G. Lindner, U. of Wis.; W. S. Bishop, M. I. T.; A. L. Stillwell, U. of Cambridge, England; G. J. Harms, U. of Kansas; F. A. Minks, Miss. A. & M.; E. F. Brooke, Ohio State U.; W. C. Ellis, Rensselaer Poly.; O. L. Walter, Oregon State College*



Top Row: R. V. Mills, Johns Hopkins; A. C. Findlay, U. of Chicago; R. L. Tambling, U. of Illinois; P. V. Koos, U. of Wis.; F. W. Boesche, Cornell; O. J. Murphy, U. of Texas; P. W. Swenson, Worcester Poly.; M. Brotherton, U. of London; S. D. White, Rutgers; M. E. Maloney, Cornell; H. W. Garbe, Kansas State; G. E. Long, Jr., U. of Iowa; C. W. Borgmann, U. of Colo.; W. H. Cortelyou, Rutgers; L. E. Brown, U. of Texas; C. E. Schissler, Johns Hopkins. Middle Row: W. G. Gustafson, Union College; J. R. Power, Carnegie Tech.; J. O. Johnson, Kansas State; J. F. Lee, Fordham; J. F. McEneany, Catholic U.; F. X. Obold, Catholic U.; R. M. James, Occidental; W. F. Jurgens, B. P. I.; L. R. Lowry, U. of Wash.; I. L. Hopkins, M. I. T.; H. G. Och, N. Y. U.; W. E. Gilson, Haverford College; L. N. St. James, Cornell. Bottom Row: H. A. Blake, Cornell; S. R. Durand, U. of Wis.; R. D. Smith, Drake; J. Donelson, Jr., Vanderbilt; W. T. Jervey, Tulane; W. A. MacMaster, Union College; A. P. Steensen, M. I. T.; P. H. Taylor, Stevens; W. F. Simpson, Carnegie Tech.; I. H. Gerks, U. of Wis.; E. J. Fogarty, Yale

our Laboratories, its purpose and its place in the Bell System, and they are also given a picture of the interrelationships of the twenty-five odd companies that compose the Bell System. Members of the technical staff describe the work of their particular departments, the problems encountered and the opportunities offered for development. Visits to various laboratories and to telephone exchanges supplement the lectures and give the newcomers a fairly broad view of the functions of the Laboratories and its contribution to electrical communication. At the conclusion of the introductory course, each new member is assigned to a type of work consistent with his training and propensities.

The group just issuing from the introductory course, like its predecessors, represents educational institutions in every section of the United States and in some foreign countries as well as various other departments of the Bell System. Wide representation is distinctly advantageous in that it brings together men with common interests but with varied backgrounds of experience. The operating companies by keeping in close contact with the engineering colleges and describing our work to qualified students have greatly assisted our Per-



Top Row: *G. Brekke, Stevens; Burton R. Cole, Stanford U.; W. W. Mutch, Wis.; C. A. Kotterman, Yale; R. C. Dehmel, U. of Cal.; C. F. Wiebusch, Texas; John R. Fincher, Cornell; John R. Flegal, Penn State; Benjamin Slade, Harvard; J. M. Hardesty, Illinois; J. H. King, Stevens; C. H. Young, Mich. Middle Row: G. F. Kern, Syracuse; W. S. Hunt, V. P. I.; E. M. Tolman, Bowdoin; L. E. Vandevere, Miss. A. & M.; J. E. Lambly, Cornell; M. A. Logan, Cal. Tech.; Frank R. Dickinson, Union; Olney B. Cook, Columbia; F. L. Morgan, Rensselaer; H. H. Staebner, M. I. T.; P. Komroff, Yale; C. L. Erickson, Kansas State; Haig P. Iskenderian, Mich.; W. A. Munson, U. of Cal., So. Branch. Bottom Row: O. W. Towner, U. of Kan.; G. R. Woodford, Mich.; M. H. Quell, B. P. I.; G. R. Harris, Carnegie Inst.; Frey Hamburger, Cal. Tech.; Ardis M. Walker, U. of So. Cal.; Thomas Pope, Illinois; H. A. Bredehoft, Kan. State; C. E. Rinehart, Oregon State College; C. H. Bidwell, Cal. Tech.; H. K. Farrar, Cal. Tech.; George Moore, Cal. Tech.; Russel Sherman, Pratt Inst.*

sonnel Department in the selection of new employees.

The Laboratories expects these new members to bring with them the habit of study and the susceptibility to instruction which has characterized their previous training and hopes that they will utilize the facilities offered for further study and advancement. They will soon begin to realize—what those of us who are older at the business know so well—that employment marks not the end of one's education but rather its beginning. On its side, the Laboratories will not forget, that although dedicated to the achievement of distinctly practical ends, it must cooperate with the members of its organization in broadening their knowledge of electrical communication. To this end and to supplement the introductory courses, many other courses both in and out-of-hours are offered.



Bell Laboratories Club

THE nominating committee of the Bell Laboratories Club will meet on Wednesday, October 26, to nominate candidates for the Club elections to be held on Monday, December 5. The offices to be filled for 1928 are as follows: President, First Vice-President, Second Vice-President (woman); Departmental Representatives — two year term—for Apparatus Development, Patent-Inspection, and Plant.

In accordance with the Club constitution, the nominating committee consists of the following members: E. J. Johnson, President; D. D. Haggerty, Secretary-Treasurer; Departmental Representatives S. J. Stranahan of Apparatus Development, J. G. Motley of Plant, A. A. Reading of Commercial, P. T. Higgins of Tube Shop, G. H. Heydt of Patent-Inspection, A. L. Johnsrud of Research, and T. J. O'Neil of Systems Development.

Club members having candidates should submit their names to their departmental representatives before the meeting. There shall be nominated at least two but not more than three candidates for each office.

Dance

A few tickets are still available for the Fall Dance to be held on the McAlpin Roof Friday evening, October 7. If you plan to attend this party, the committee suggests that you buy your tickets at once. The management of the Hotel McAlpin has limited the sale of the tickets to five hundred and will not permit the sale of tickets at the door the evening of the dance. Buy now and be one of the lucky five hundred.

Music will be furnished by Deacon Johnson and his colored entertainers, who have furnished music in the past for the Hotel Martinique, the Bellevue-Stratford and the Hotel Astor. Dancing will be from nine until two.

Club Orchestra

The orchestra held its first 1927-28 rehearsal on September 27, with excellent prospects for a successful season. At the close of last season, it was felt that such advancement had been made that the services of a professional director were essential to further progress. During the summer months a great deal of work was done by the officers along this line and a director was secured. Mr. Egon Ebert, who began his season's activities with the Club by conducting the opening rehearsal, was secured through the co-operation of the American Orchestral Society. This

organization handles the training of conductors for the New York Philharmonic Orchestra and practically all of the symphony orchestras in America. Mr. Ebert has studied in the conservatories of Krefeld, Germany, and Milan, Italy, and is now connected with the conductors' school of the American Society upon whose recommendation he came to us. Those who attended the opening rehearsal were unanimous in their approval of the excellence of Mr. Ebert's work and in their enjoyment of the evening's activities.

The employment of a professional director for our orchestra can only be justified if it results in bringing together all the musicians in the building who play any orchestral instrument. The degree of ability of the performer does not constitute any obstacle. It is the function of the director to solve that problem.

If you play an orchestral instrument, if you enjoy playing it, if you want to play it better and thereby increase your own enjoyment and add to that of others of like tastes—then the orchestra wants you at the next rehearsal. Auditorium—Tuesday evenings, at six o'clock.

Basketball

On Thursday, August 11, in the office of Mr. Stevens at 195 Broadway, was organized the Bell System Basketball League. The companies represented in the league are as follows:

Western Electric, G. H. Q.
Western Electric, Installation.
Western Electric, Telephone Department, Hudson St.
Bell Telephone Laboratories.
New York Telephone, Northern Manhattan.
New York Telephone, Southern Manhattan.
New York Telephone, Westchester.
New York Telephone, Long Island.

All the games will be played in the gymnasium of the Stuyvesant High School, First Avenue and Fifteenth Street, on Monday and Wednesday evenings; two games on each evening. The first game on Monday nights will start at eight-fifteen, and on all Wednesday evenings the first game will start promptly at seven-thirty. There will be dancing between the halves and after the games until eleven-thirty.

Season tickets which will entitle the holder to be admitted to all fourteen evenings of play will cost one dollar each. Tickets for individual games are twenty-five cents each. The schedule of Club games is as follows:

October 26—Western Electric, Inst.
October 31—New York Tel., S. Man.
November 9—New York Tel., West.
November 14—New York Tel., N. Man.
November 28—New York Tel., L. I.
December 7—Western Electric, G. H. Q.
December 14—Western Electric, Hudson St.

The Bell Laboratories Club Interdepartmental League will start on Tuesday evening, November 1, at Labor Temple, Fourteenth Street and Second Avenue. Two games will be played every Tuesday and Thursday evenings, with the first game starting promptly at five-thirty. Eight teams representing the various major departments of the Laboratories will take part in the 1927-28 tournament: Plant, Research, Equipment Drafting, Systems Engineering, Apparatus Development, Junior Assistants, Tube Shop and Commercial.

All men in the Laboratories are cordially invited to take part in the basketball activities of the Club. If any Club member has not played with the Club team previous to this season, he is invited to call on D. D. Haggerty, Room 164. The Club is especially anxious to hear from men who have had basketball experience, whether it be with local teams or school or college organizations.

Our team in the Bell System League will be managed by J. A. Waldron and the activities of the interdepartmental league will be directed by T. J. O'Neil. Either of these men will be glad to tell you more about the basketball activities and furnish information regarding the nights on which try-outs will be held for the league team and practice for the interdepartmental organizations.

Women's Activities

Basketball. Everyone is anticipating an interesting and exciting season for the Women's Basketball Team. Beginning October tenth we have practice nights the tenth, seventeenth, twenty-fourth, thirty-first; November fourteenth, twenty-first, twenty-eighth; and December fifth and twelfth, with Mr. A. Turner as coach. Along about the middle of this period we expect to separate the group into two teams, one playing Modified Girls' and the other Boys' Rules. With two teams ready to meet anyone we expect to line up games for practically all the Monday nights from January ninth to March twenty-sixth.

If you are acquainted with any



Plant Department team, winners of the Interdepartmental Baseball trophy: Left to right, standing—G. F. Kallensee, 3rd base; A. Hansen, 2nd base; W. Flynn, 1st base; J. Jorgensen, Pitcher; W. Eichinger, Right Field, and J. M. Veseley, Center Field. Left to right, sitting—W. S. Haffner, Left Field; J. H. Westenberger, Pitcher; C. A. Grant, Manager; W. Bodenstedt, Catcher, and C. Schepperle, Short Stop

girls' teams, send the manager's name to Marie Boman that she may arrange a game with them. Our team will play Monday evenings at the Manhattan Trade School Gym, Lexington Avenue and Twenty-second Street, from five-thirty to seven-thirty.

Swimming. Swimming Classes are held at the Carroll Club Pool, 120 Madison Avenue, Mondays, seven to seven-thirty and Wednesdays five-thirty to six. The charge is two dollars and fifty cents for eight lessons and the lesson period covers ten weeks. Miss Steil is again in charge and will continue the instruction with those who started last year as well as give instructions to the beginners.

Dancing. The Physi-cultural Dancing Class is ready to start its fall season the middle of this month at Louis Vecchio's new studio, Broadway at Twenty-seventh Street. The new studio is better equipped than the old one and has larger dressing rooms. We hope to continue the fun we all had last year and that many new recruits will join the class. The course of ten lessons costs five dollars.

Bridge. The women plan to play their first game of bridge for the season in the Rest Room, Tuesday, October 4, at five-fifteen. In order to help Miss Murtagh to arrange the prizes, will all those who wish to play be sure to return the game card to her by Monday each week.

Hiking. The hikers seem to be all set for plenty of exercise this year, although with due consideration to those of us who only plan to go out occasionally, they have included several short walks and campfire suppers.

This is the schedule for October. Just let Miss Barton know if you wish to join them at any time, in order that she may provide enough supper.

Saturday, October 1: this will be an eight-mile walk from Summit, New Jersey, through a reservation of Essex County. There will be a campfire supper. Cost, about one dollar and sixty cents. Meet at entrance of the new building at twelve-thirty.

Wednesday, October 12 (Columbus Day): meet at Erie Station, tube waiting room, Jersey City, at nine, to walk from Sterling Forest to Tuxedo. Distance, fifteen miles. Cost, about two dollars and fifty cents, using ten-trip tickets. This is a good walk, combining cross-country trails and dirt roads.

Saturday, October 15: meet at the entrance of the new building at twelve-thirty to walk from Englewood to Alpine. Camp-fire supper at end of the hike. Distance, six miles. Cost, including supper, seventy-five cents.

Sunday, October 30, a pleasant fifteen miles over trails and dirt roads in the country around Croton Lake. We will pass the dam, which is one of the finest pieces of masonry in this part of the country. The trip will cost about two dollars and fifty cents.

BELL LABORATORIES RECORD

WORKING THE BASE METALS

By J. H. White

ECHO ELIMINATION

By G. C. Crawford

50 KW. BROADCAST TRANSMITTER

By A. W. Kishpaugh

NOVEMBER 1927 VOL. 5 NO. 3

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Bell Laboratories Record

Volume Five NOVEMBER, 1927 *Number Three*

Power Rating of Broadcasting Transmitters

By O. M. GLUNT
Assistant Apparatus Development Engineer

RECEPTION of low-powered broadcasting stations at far distant points is interesting and often very remarkable. The real work of the broadcaster, however, is to make possible the flawless reception of programs and to provide an unfailing service over as large an area as possible surrounding the station. For broadcasting purposes no advantage can be taken of the vagaries of transmission or of any directive effects and, therefore, improved reception and reception over greater areas must be had either by the generation of more power or by the more effective utilization of the power that is generated. There are certain obstacles, such as fading and interference, which cannot be wholly overcome by the expedient of using a large amount of power, but high power tends to mitigate their effects as well as to increase the area of high grade reception.

It is possible that the maximum power to be used in broadcasting will eventually be fixed primarily by technical difficulties, but at present the determining factors are largely economic. In general, the cost per unit area served decreases as the power and area are increased, so that with the present trend toward the broadcasting of better and more expensive programs, economic considerations point to increasing the areas regularly reached by most stations. Although the situation as it confronts each broadcaster must be analyzed by himself, taking account of the extent and character of the population which it is useful for him to reach, there seems little doubt but that the future will bring with it an increase in the power of most broadcasting stations.

In this connection the general adoption of a comprehensive method of rating the output of broadcasting transmitters is important. A rating now commonly used merely expresses the unmodulated high frequency power delivered to the antenna and on this basis broadcasting transmitters are referred to as one-kilowatt sets, five-kilowatt sets, and so on. This method of rating, while it is based upon a definitely measurable quantity, is quite inadequate,

failing as it does to take into consideration the maximum obtainable percentage of modulation. This is an equally important factor in determining the effectiveness of the power in the distribution of a program, and the complete specification of the performance capabilities of a transmitter must be expressed in terms of both of these factors: power output and percentage of modulation.

Most readers have observed in tuning their radio receivers that the presence of a carrier even when unmodulated can be detected by an increase in the noise received. Most of this noise is static or local electrical disturbances "beat in" by the carrier, although the latter in itself is inaudible. The loudness of this noise is proportional to the carrier amplitude and independent of modulation. The program signal on the other hand is proportional to both the carrier power and the percentage of modulation. To obtain the best signal-static ratio, therefore, it is important that a high degree of modulation be attained. It can be shown that from a signal-static ratio standpoint a one-kilowatt broadcasting transmitter capable of one hundred percent modulation is substantially equivalent to a five kilowatt broadcasting transmitter capable of forty per cent modulation. The importance of complete modulation has not yet been generally realized among broadcasters or listeners and it is probable that the modulation of most of the existing stations can be increased, thereby affording greater coverage without the radiation of any more carrier power.

It is not a simple matter, however, to adapt the apparatus of a given station to a higher percentage of modulation. It may mean certain new equipment capable of handling the greater peak power which increased modulation entails. As between two stations each capable of generating the same carrier power, that possessing the greater degree of modulation will, in general, be more expensive to build especially in the larger units.

The question is sometimes raised as to the extent to which modulation can be carried without loss of quality. Recent tests conducted by Bell Telephone Laboratories indicate that modulation at peak values of the audio wave may be carried to one hundred per cent without perceptible sacrifice in this respect. The new fifty-kilowatt set which is now under test at our laboratory in Whippany, N. J., is capable of this performance and extensive investigations have proven that its quality is excellent.

The Fifty-Kilowatt Radio Transmitter

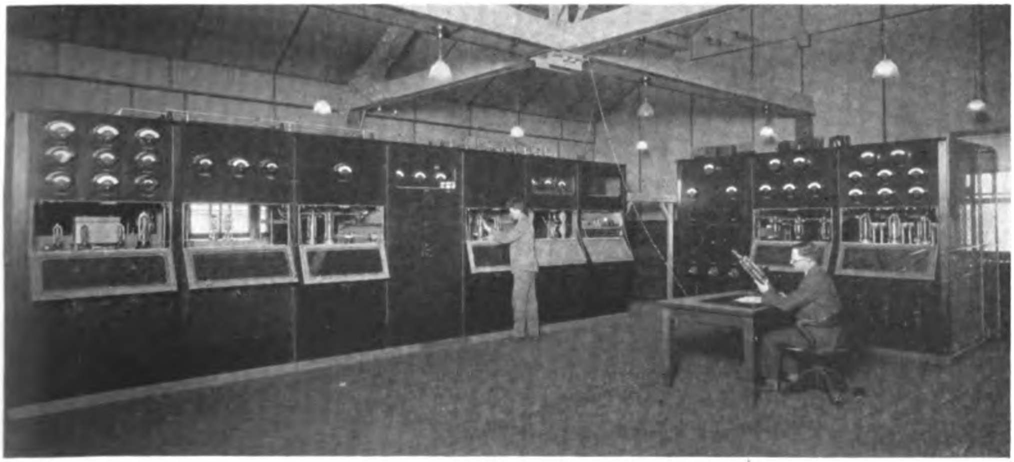
By A. W. KISHPAUGH
Apparatus Development Department

MANY late-at-night radio listeners during the past months have been surprised at hearing, with more than ordinary volume, music and speech which in due course they find to have been transmitted from our Laboratories' experimental station at Whippany, New Jersey. These listeners have been scattered over a considerable portion of the United States and some have been located at far distant points outside of this country. Reports of reception have been particularly gratifying since the tests have been carried on during the summer, a time generally unfavorable to good radio reception.

The particular equipment used in the tests at Whippany is the development model of the Western Electric 7-A Radio Broadcasting Transmitter, rated at 50 kilowatts. It has been created to make possible the provision over areas of reasonable magnitude of broadcasting service consistent with the ever growing requirements of the art.

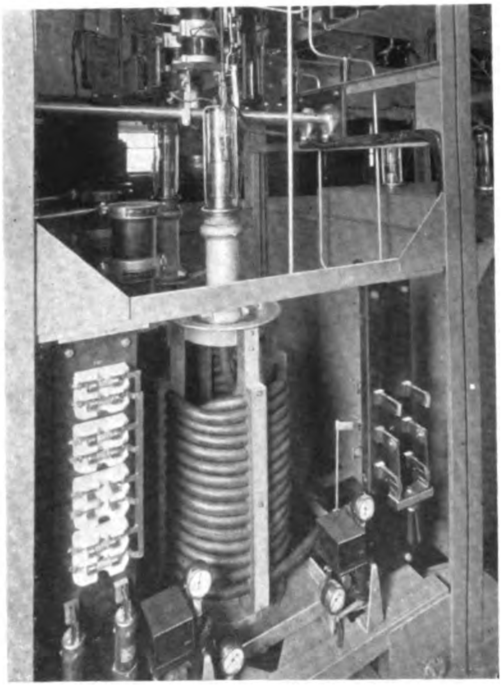
The transmitter uses twenty-five vacuum tubes, of which fourteen are water-cooled. These tubes and their related circuits are mounted on and behind ten panels; on a floor below are installed some of the bulkier pieces of apparatus such as transformers, generators and filters. While the normal unmodulated output to the antenna is fifty kilowatts the tube capacity is adequate to deliver the 200 kilowatts which are required during peaks of modulation.

With so many broadcasting stations on the air, it is of first importance that each one maintain its carrier frequency constant at the value assigned by the Federal Radio com-



A general view of the transmitter room at Whippany

mission. To this end, the frequency of the carrier-wave is controlled by the oscillation of a small quartz plate. Cut from a single crystal, with proper

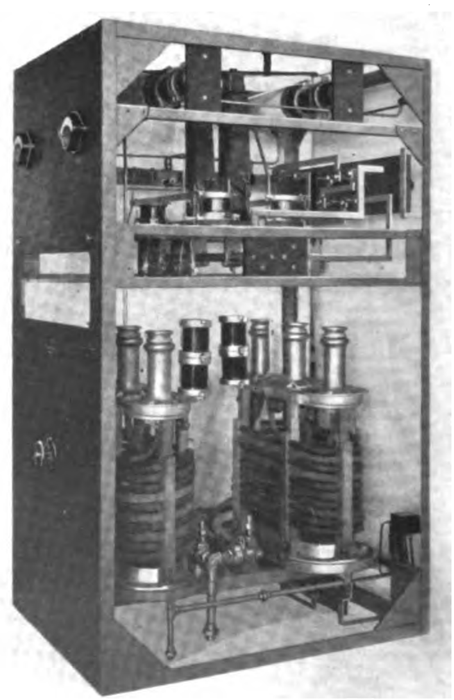


Rear view of the tube unit for the next-to-last stage

orientation as to the crystalline and optical axes, the quartz plate, carefully ground to a thickness determined by the desired frequency, is then associated with a master oscillating circuit. As one precaution to ensure constant frequency, the plate is mounted in a container where its temperature is held constant.

Speech currents from the control room are amplified by two stages in the set proper; the output voltage from the last of these is used for modulation. The radio frequency generated by the vacuum tube under control of the crystal is amplified in five stages. On the plate voltage of the second-stage tube is superposed the audio-frequency voltage for modulation. The audio-frequency voltage is sufficient to effect complete or one hundred percent modulation of the carrier oscillation. The importance of this is discussed by Mr. Glunt in his foreword. The modulation stage is followed by three more stages of radio frequency amplification, each of which is a push-pull circuit. Water-cooled tubes are used in the last two stages: two in one and six in the other. Tuned circuits form the inter-stage couplings and also transfer the output power to a transmission line which leads out to the antenna system. In the final tuned circuit, currents as great as one hundred amperes may flow through the heavy copper tubing of the inductance coils.

Power for the set, amounting to about 250 kilowatts, is drawn from central station lines as 440 volt, 60-

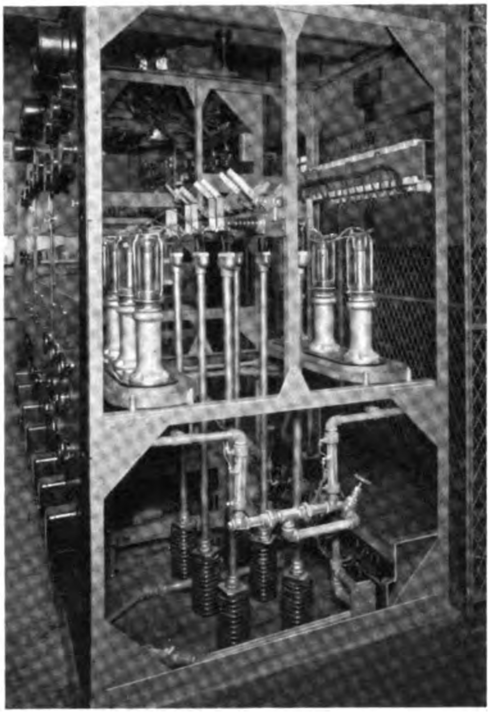


A side view of the last-stage tube unit before the tubes were placed in their jackets

cycle, three phase alternating current. A major portion of this power goes to a six-phase vacuum-tube rectifier which supplies direct current at 17,000 volts to the last two radio stages. Direct current from a 1500-volt rectifier is supplied to the other stages. One motor-generator set supplies about 550 amperes direct current to the amplifier filaments; another set supplies grid-bias voltages. Outputs of both these generators pass through filters, that for the filaments using electrolytic condensers and a large choke coil.

To prevent excessive heating and consequent damage to the vacuum tubes, provision must be made to remove the heat generated in operation. For many of the tubes, radiation into the air is sufficient, but for others water cooling is necessary. These tubes are inserted in jackets through which water flows in contact with the tube anodes. Water is led to and from the tube jackets through lengths of coiled hose. This is to provide the necessary insulation between jackets, which are connected with the anodes and therefore at high potential, and the other parts of the cooling system which are grounded. The water in turn is cooled by radiators through which air is forced by large fans. About a hundred gallons of water a minute flow through the cooling system; should the water cease to flow, or should its temperature rise beyond a safe value, power is automatically removed from the tubes.

The layout of the Whippany laboratory includes a control room where the speech input amplifier and related equipment are located. Adjoining it is the transmitter-room itself. Along one wall of this room is an assembly fronted by seven panels housing the audio and radio frequency circuits. At the end of the room is a group of three panels: one for general power control, which carries the push-buttons by which the set is started and stopped; one for the 17,000-volt rectifier and one for the 1500-volt rectifier. Tubes for



An end view of the power supply group showing the 17,000-*volt rectifier tubes*

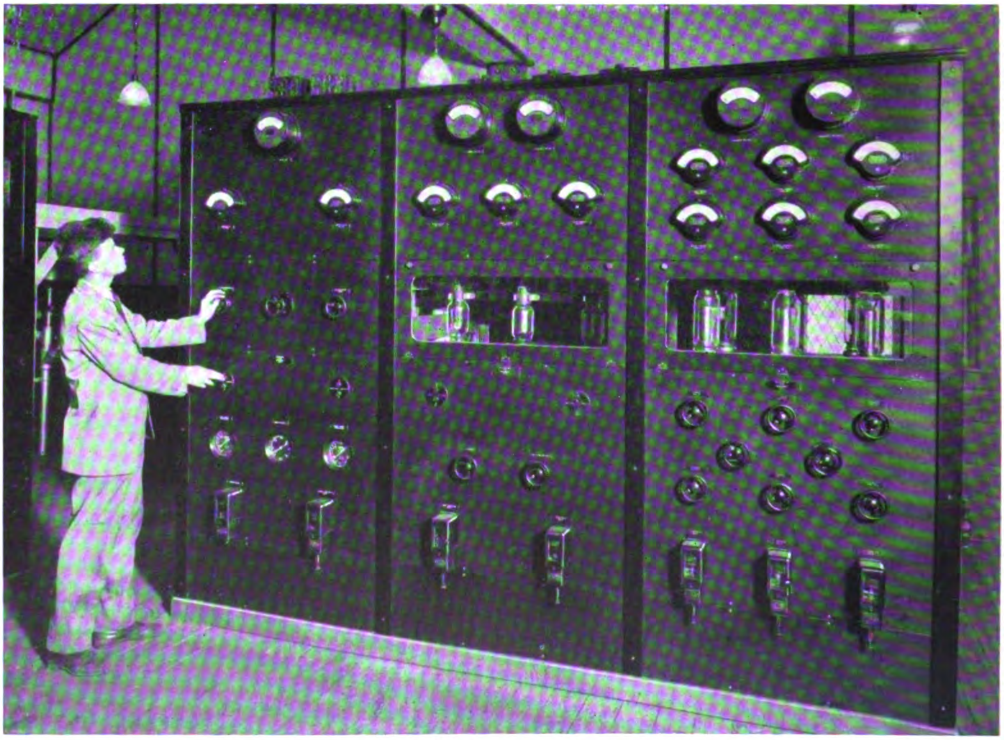
these rectifiers are mounted behind their respective panels. The transformers and filtering equipment for the higher-voltage rectifier is located directly beneath, on a lower floor. On this floor are also the motor-generator sets.

In order to keep the station and its equipment outside the more intense field of the antenna, connection is made between the transmitter and antenna by a two-wire line about five

hundred feet long. The voltage between wires is approximately six thousand and the line functions as any other though the power is transmitted at a very high frequency. The tuned circuits for coupling to the antenna are located in shielded compartments at the end of the transmission line directly beneath the antenna.

Much thought has been given to the protection of the operating staff against high voltages. Throughout the transmitter access is had to the circuits through doors and windows which must be securely locked before the circuits can be energized; in order to open these points of access it is necessary to unlock them through a mechanism which first disconnects the power supply and grounds the high voltage parts. All parts requiring adjustment or replacement are readily accessible. Other portions of the apparatus are arranged with a view primarily to the compactness of the equipment. This promotes economy in floor space, facilitates protection, and enables important elements to be observed by a minimum of personnel.

Satisfactory service to broadcast listeners—the sole justification of any station — requires that everything possible be done to minimize interference with other programs. To avoid the annoying "whistle" which results from heterodyning of its carrier with that of a station occupying an adjacent frequency-channel, the carrier must remain very close to its assigned value. This requirement is well met through crystal control. Moreover, radiation of harmonic frequencies must be as little as possible, since this is in effect a transmission of



The power-supply group; the panels are respectively for power control, for the 1500-volt rectifier and for the 17,000-volt rectifier

the program at a frequency which may conflict with that assigned to another station. The disturbing effect of harmonics being proportional to their absolute value, special precautions must be taken in the construction of so powerful a transmitter. Careful shielding of the circuits, together with the form of the circuits themselves, have served this purpose so well that the radiation of second harmonic is approximately one tenth watt—that is, one five-hundred-thousandth of the fundamental radiation.

Addressing the National Association of Railroad and Utilities Commissioners, President Gifford said:

"Professor Cabot of the Harvard Business School made the following comment on the Bell System: 'The thing is a modern miracle which I can only explain to myself by assuming that the men who conceived, created and have developed the telephone were men of the rare automotive type whose driving power came from within, and who, therefore, did not need the external stimulation which competition alone can give.'

"Undoubtedly a very great factor in continued progress and improvement of telephone service is the intangible but quite real spirit of service that has become a tradition in the telephone business, but the results of the Bell telephone business have a broader foundation than the one Professor Cabot has recognized. It is fundamental in our plan of organization to have at headquarters and in our laboratories several thousand people whose sole job it is to work for improvement. They are engaged in studying what is used in the telephone business and how it is used and endeavor to find a better thing or a better way. Of course the people engaged day by day in trying to maintain a high standard of telephone service are doing their part, and a most important part, in increasing quality and keeping down cost of service, but progress is assured by having a large group of scientists and experts devoted exclusively to seeking ways of making the service better and cheaper."

Working the Base Metals

By J. H. WHITE
Research Department

THE laboratory for working base metals began its existence some ten years ago during the development of loading coils with cores of compressed iron dust. Its first equipment included mills for grinding the specially embrittled electrolytic iron, machinery for sieving, annealing and heat treating it, and a one-thousand ton hydraulic press for compressing the iron dust into strong coherent cores. At the present time the laboratory equipment is used very largely for the production of magnetic alloys in various forms but in addition considerable work is done with aluminum alloys for diaphragms, with lead alloy for cable sheaths, and with brasses, bronzes, and steels for a variety of purposes. Individual machines are not large compared to those of industrial plants, due to the fact that they are used for experimental batches only; but their variety and versatility is great.

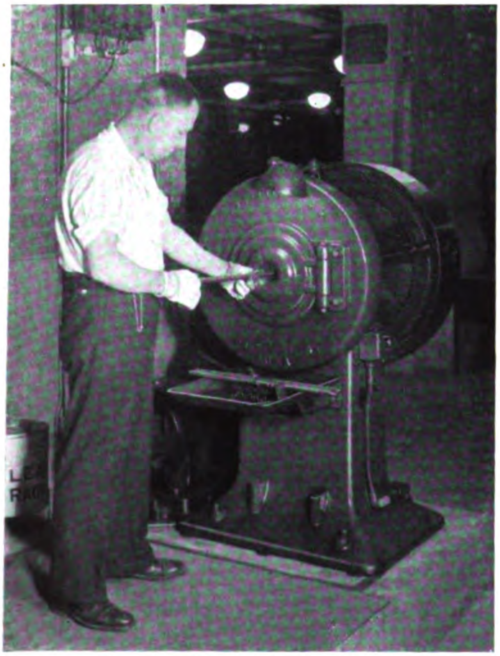
The laboratory's equipment and its use may well be illustrated by following the process of manufacturing experimental quantities of permalloy tape such as are used for development work on continuous loading of submarine cables.

The purest nickel and iron obtainable are melted together with every



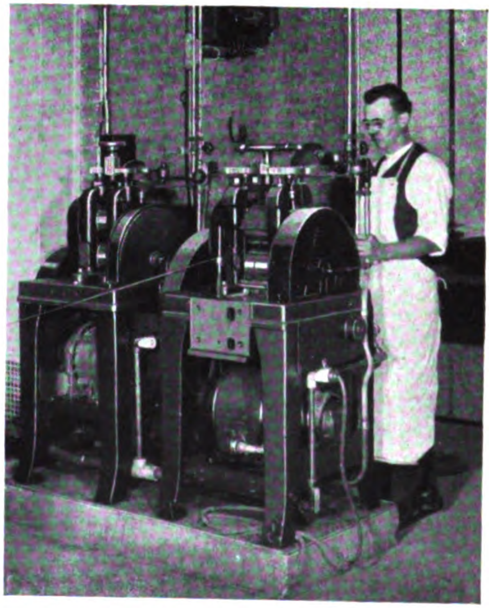
O. J. Barton prepares to pour a "melt" from the induction-furnace

precaution to prevent the melt from being contaminated with foreign substances. A crucible of pure quartz is used to avoid impurities that might be present in the less expensive re-



Four thousand blows a minute are struck on the permalloy rod as M. Tompa feeds it into the rotary swaging machine

fractory materials. A high-frequency furnace of the induction type serves a similar purpose as it eliminates contamination by the fuel or electrode materials which are used with the commoner methods of melting iron. After the metal has melted it is poured into a cylindrical iron mold three quarters of an inch in diameter and sixteen inches long. When the alloy has cooled, a long series of reducing operations ensues before the permalloy assumes its final shape. Cold swaging, or cold or hot rolling, follow in a score or two of successive steps or "passes," until the rod becomes a wire about one tenth of an inch in diameter. The rotary swaging machine is far superior to other means of reduction of metals which are difficult to work. This machine contains ten hammers, which deliver four thousand blows a minute upon a split die whose central tapered hole has a minimum diameter slightly less than the size of the initial bar or wire. A succession of such interchangeable dies of progressively smaller diameters is used. Such treatment gives a very gradual reduction with a minimum of strain. Many of the alloys which have been made in the laboratory could have been reduced in size by no other means as they were not strong enough to with-

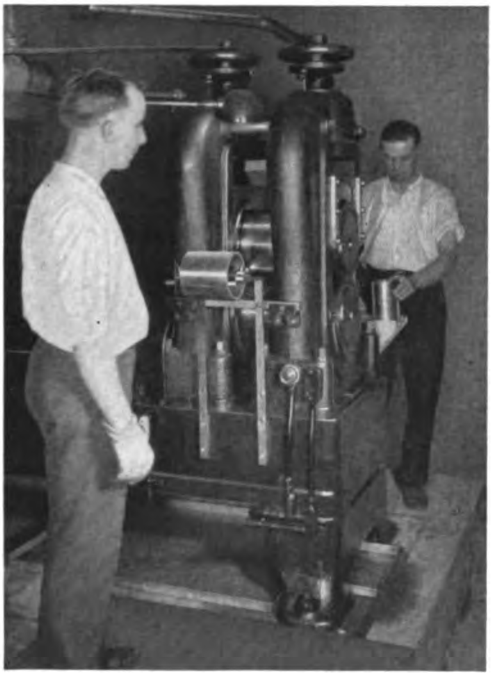


A permalloy wire is flattened into tape under the supervision of F. C. Kahnt

stand a rolling or forging operation.

At definite stages between the rolling or swaging processes, the metal is annealed to remove strains set up by working. Before the rod has been reduced sufficiently to be called a wire it is heated for annealing purposes by passing an electric current through

it; suitably low voltage is secured from step-down transformers. After the rod has become a wire one tenth of an inch in diameter, it is coiled up and put in a metal pot in an electric



R. J. Riley and J. M. Artiges roll out a sheet of diaphragm stock

furnace for a long anneal. Precautions are taken to prevent oxidation during this process. After twenty-four hours the wire, which entered the pot somewhat tarnished, emerges with a brilliant lustre. By this prolonged anneal the wire has become very soft and can thereafter be drawn down through steel dies without difficulty. The drawing operation is much more rapid and proceeds with little attention from workmen.

Frequently it is necessary to draw wire to extremely fine sizes. Then diamonds are used for the dies on account of their hardness, the diamond being the only material that can be used when great lengths of wire must be drawn to diameters kept within narrow limits of accuracy.

After the drawing process, the permalloy wire is flattened by being passed through rolls. As before it is frequently annealed, each treatment removing the hardness caused by the previous working. At length, after its long journey, it appears as a flat tape, about one eighth of an inch in width and six thousandths of an inch in thickness, ready to be applied to the cable conductor. A similar process is carried out at Hawthorne on a commercial scale.

Some of this laboratory's output of permalloy takes the form of rods, wire or narrow rolled sheets. Permalloy dust is also produced: the cast



C. V. Wahl heat-treats duralumin diaphragms

ingot, properly embrittled, is hot-rolled to develop the proper grain-structure and is then reduced to powder in ball-mills.

Aluminum alloys are of importance in the communication art; their combination of strength and lightness makes them well suited as diaphragm

material. Sheets of these alloys are rolled out to thicknesses as small as three thousandths of an inch. Lead alloys suitable for cable sheathing also have their share of attention; after melting, to insure proper alloying the metal is cast into slugs and extruded by a thousand-ton lead press into the form of samples for further tests of strength, fatigue, resistance and corrodibility and the study of changes of these properties with time.



The wire-drawing bench is one of the oldest of metal-working machines. Its modern counterpart in our Laboratories is operated by D. Wallace

Since the metal working laboratory is used only for experimental purposes variety is the keynote of the alloys produced as well as of the equipment used. In the permalloy group alone there is an indefinite number of proportions in which the iron and nickel may be mixed which results in products of different magnetic qualities. Sometimes other metals are also added in small quantities to give some particular characteristic. The same is true of the aluminum and other alloys that are handled in the base metal laboratory. The expeditious production of varied forms of metal with a minimum loss of material is dependent no less on the skill and experience of the chemists and metallurgists engaged in the work than on the completeness of the equipment.

Echo Elimination in Transatlantic Service

By G. C. CRAWFORD
Systems Development Department

STAND a thousand feet from a cliff and shout toward it. About two seconds later your voice, having travelled to the cliff and bounced back, will return to you. This phenomenon, called an echo, may occur also on telephone circuits when the electric current meets any sudden change in circuit conditions, such as a change from open wire to cable. Under these conditions, part of the current is reflected from the point where the change occurs and returns back over the circuit to its source where it reproduces, with reduced volume, the sound sent out. A telephone echo, however, is not always caused by a reflection. Anything allowing a portion of the current to return to its source will produce the same effect.

The seriousness of an echo depends not only on its volume but on the time interval by which it follows the original sound. Just as the echo present in a small room is not troublesome, so the echo on relatively short telephone lines is not noticed by the user. In these cases, the echo occurs practically simultaneously with the original sound. But in loaded cables the time of transmission is much increased, and the longer distances over which such cable is now used are sufficiently great to cause trouble from this source. One of the most serious forms of echo develops on four-wire cable circuits. It is caused by an inequality of impedances of two-wire circuit and network associated with each hybrid coil so that part of the current is allowed to return to its source.

The four-wire circuit shown in Figure 1 illustrates a typical set of circumstances. Assume this represents a cable circuit from New York to Chicago. The little squares marked

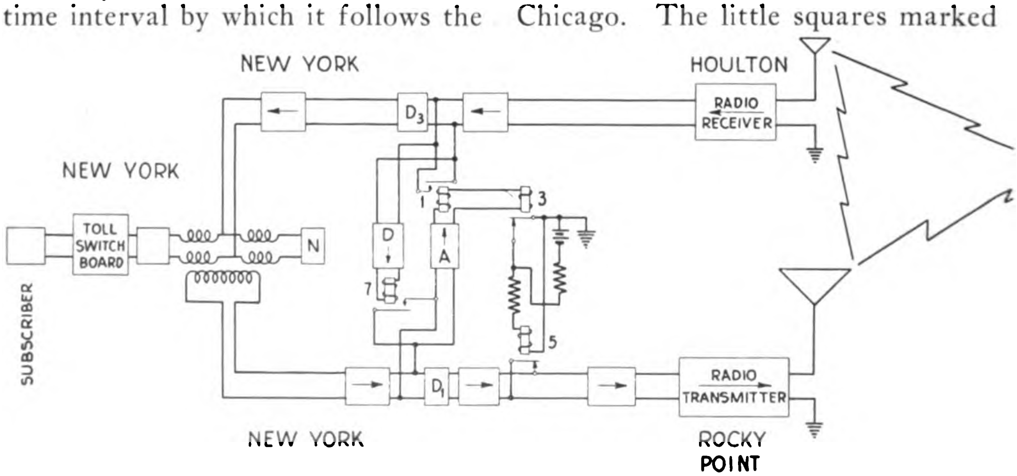


Fig. 2—The New York and London circuit showing similarity between it and a four-wire land circuit

with an arrow are repeaters and those enclosing an "N" are the balancing networks. The voice current leaving New York passes through the hybrid coil and continues by the lower path toward Chicago where it arrives about five hundredths of a second later at the central point of the hybrid coil. If the balancing network at Chicago were a true equivalent of the local circuit, the arriving current would split in two, half going to the network and half to the receiving station. As the currents in the balanced windings are equal but opposite in direction there would be no resulting induced current in the upper path.

If the network is not an exact balance, however, and it never can be made so practically, there is an inequality in the current in the two branches which will induce a current in the upper circuit. This current will return to New York which it reaches in another five hundredths of a second, or one tenth of a second after it left. The result will be an echo in New York. Due to the unbalance at New York this first echo will induce a current in the output circuit of its hybrid coil which will travel back to Chicago, producing an-

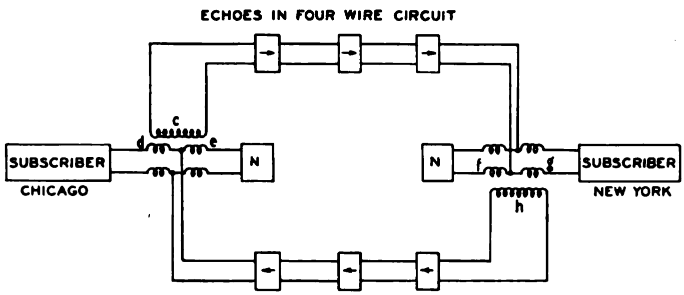


Fig. 1—*Diagrammatic representation of four-wire circuit between New York and Chicago*

other echo there. If the gain in the repeaters were sufficiently great—greater than the loss in the hybrid coils and the line—this circulating echo would continue indefinitely, producing singing and making conversation impossible. In general, telephone circuits are so adjusted that the size of the echo is well below a value that could possibly cause singing.

The transatlantic service is essen-

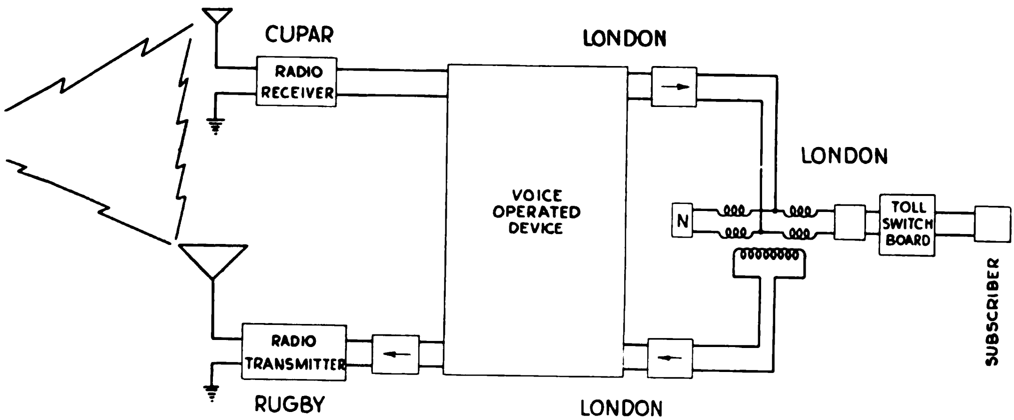


Fig. 2—*The New York and London circuit showing similarity between it and a four-wire land circuit*

tially a four-wire circuit; the east bound side running by wire from New York to Rocky Point, thence by radio

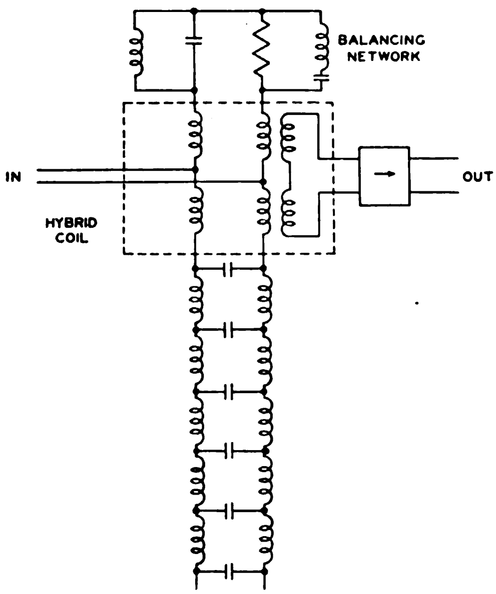


Fig. 3—Schematic representation of the delay circuit used with the voice operated relays

to Cupar and from there to London by wire, while the west bound side runs similarly from London to Rugby, to Houlton and to New York. Due to this it is subject to the same echoing that may disturb any four-wire circuit. Because both Rocky Point and Rugby transmit at the same wave length, however, a condition exists which in a sense reunites the two paths for the length of the radio circuit. In a normal four-wire channel the circuits in each direction are physically separate so that leakage can not occur from one to the other, while in the transatlantic this separation breaks down over the radio path. The speech waves outward bound from Rocky Point will be picked up by Houlton and from there will be returned to New York as an echo.

Due to the large power of the transmitter necessary to work across the Atlantic, and to the high gain in the receiving circuit, not only echoes but singing might occur around the local circuit—New York, Rocky Point, Houlton, and New York—if positive measures were not taken to avoid it. For this purpose voice operated relays are installed at New York which exercise such control over the transmitting and the receiving circuit that they can not both function at the same time. Voice operated devices accomplishing a similar function are used at the English end of the circuit.

The method of operation of these devices at New York may be followed in Figure 2. A small portion of the voice current, outward bound from the hybrid coil at New York, is picked up by an amplifier-detector A. The amplified and rectified voice current leaving the amplifier-detector operates the relays 1 and 3. Relay 3 in turn operates relay 5, which removes the short circuit that is normally across the outgoing circuit. Relay 1 shorts the incoming circuit to prevent all echo and singing effects.

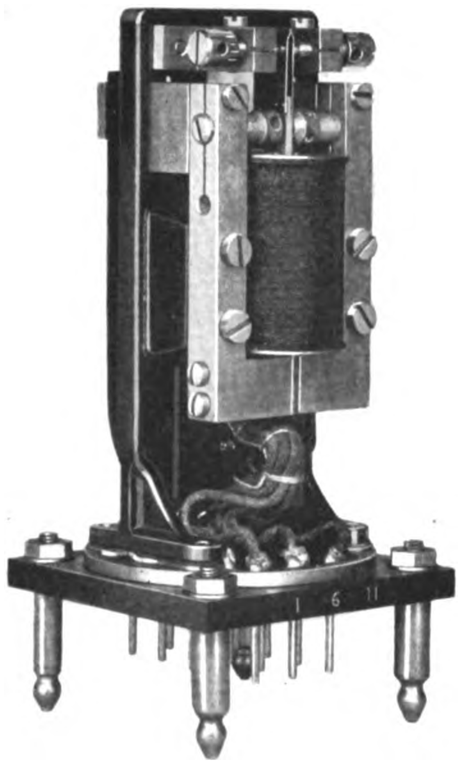
There are complicating features however. No mechanical relay can operate instantly. From six to ten thousandths of a second is consumed by the operation of the relays used with this apparatus. Also, which is of even more importance, the voice sounds require an appreciable time to build up to the value required to operate the relays. Due to this, relay 5 would remain closed for a short time after the conversation had started causing the first part of each outgoing sound to be absorbed. To avoid such a thing a delay network—D_1—is inserted to retard the voice

current about twenty-two thousandths of a second. This gives relay 5 ample time to operate.

When transmission is in the opposite direction the incoming message, through an amplifying detecting device D, operates relay 7, thereby short-circuiting the outgoing circuit. This is done to prevent the incoming current passing through the hybrid coil and operating the amplifier-detector A in the outgoing circuit which would operate relay 1, short-circuiting the incoming speech. To prevent such an occurrence before relay 7 has had time to operate, a delay network—D_3—has been inserted which holds up the voice for eleven thousandths of a second. This is sufficient time to allow relay 7 to operate, making any such action impossible.

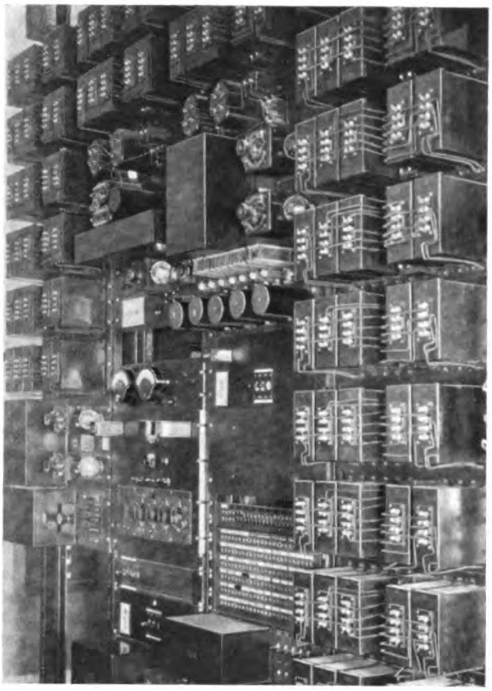
Still other refinements are necessary. After the voice current terminating a phrase in New York passes the point where the amplifier-detector is connected, the current holding relay 3 open will stop flowing. The circuit would therefore be shorted before the speech, held up by the delay circuit D_1, was ended. This condition is aggravated by the slow dying down of the voice currents toward the end of a sound. Their value drops below the amount necessary to hold relay 3 open an appreciable time before the sound is actually completed. To avoid such chopping off of syllables a time-delay is incorporated in relay 5 which holds it open long enough for all voice currents to pass through the delay circuit D_1, to the point where the contacts of relay 5 are located. This is obtained by a circuit, not shown on the diagram, which allows a condenser to be charged through the winding of relay 5, holding it open for a short time after relay 3 has closed. The charging takes place through a resistance and the time required is sufficient to allow the voice currents to pass through the delay circuit.

The echoing, which may be so detrimental to telephone conversations and has made necessary the use of these voice operated relays, is employed to good advantage in the delay networks used in conjunction with them. As has been mentioned before the harmful effect of the echo is due to the time required for the electric



Sensitive relay used for echo elimination on the transatlantic service

current to pass through the circuits. The velocity of a current in an open wire circuit with little inductance or capacity is high, approximating that of light, but in loaded cable circuits



Panels mounting the delay circuits and voice operated relays. The five cylindrical covers in the center of the picture enclose the relays while the sections of the delay circuits are in the rectangular boxes mounted all around them

is much less; the more inductance and capacitance the lower the velocity. The delay circuits are thus made up of sections of reactance and capacitance. To get the required delay of twenty-two thousandths of a second, it was found that 288 sections would be required. This was cut in half by taking advantage of the echo effect. The input to the delay circuit is connected to the central points of a hybrid coil as shown in Figure 3. The current here divides, half being absorbed in the balancing network while half goes into the 144 sections of artificial line. This is open circuited at the end causing the current to be reflected or echoed back. In returning it passes again through the 144 sections of line and through the hybrid coil in such a way as to induce a current in the output circuit. This is amplified and continues as the delayed speech.

Echoes have their advantages, therefore, as well as their disadvantages. True engineering lies in taking advantage of their good points and suppressing their bad. The delay circuits and voice operated relays show how effectively this is done on the transatlantic circuit.

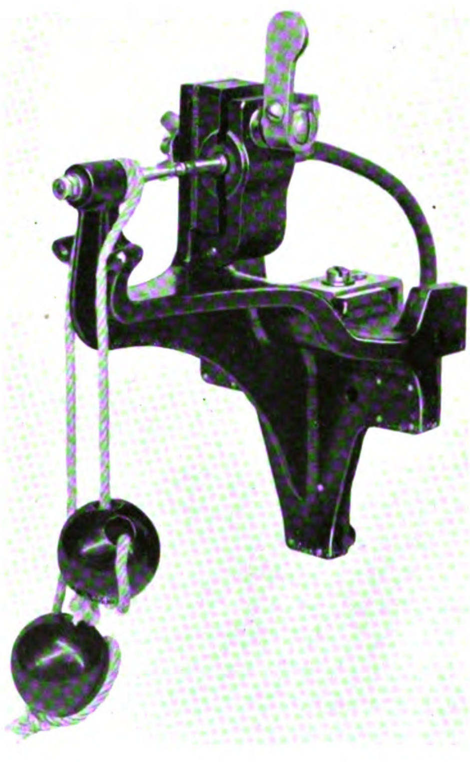
Polishing the Contacts of Telephone Plugs

By W. J. ADOLPH
Apparatus Development Department

FROM extensive handling the contact surfaces of switchboard plugs gradually become covered with a thin film of dirt and grease, which if neglected might prevent satisfactory electrical contact. Accordingly, the plugs are cleaned at regular intervals to prevent circuit noise and to keep transmission at a high level. A portable buffing wheel driven by an electric motor has long been used, taken in turn to the various switchboard positions. While this method is rapid, and on most of the contact surface quite effective, it has one serious limitation. The tip and ring contacts are lower than the sleeve and the dead-collar; to reach the depressed surfaces, the upstanding ones get rather more than their share of rubbing. It seemed that more thorough cleaning and appreciably longer plug life might be secured by a change in method.

First was tried replacement of the buffing wheel by a rotating wire brush. But the contact surfaces, although they looked quite clean, were shown by noise and transmission tests to be worse after cleaning than before — the metal brush had not rubbed the dirty film away, but merely burnished it onto the surface. Further tests showed that best results were obtained when the plugs were rubbed slowly, with comparatively heavy pressure, and when a fine-gained polishing paste was used.

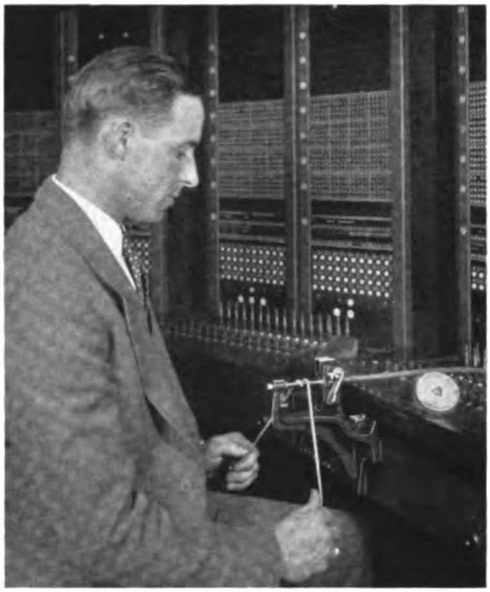
Based on these experiments a simple cleaning procedure has been adopted, using as a medium a short length of braided cotton cord coated at one end with polishing paste. The cord is looped around a plug and pulled back and forth, rubbing all the way around; first the coated end is used, to scour away the dirt, and then the comparatively dry, dirty powder is rubbed away with the other end of the cord, or with a rag. Rubbing speed and pressure naturally applied



Polisher with plug inserted, ready for use

by a user are in the proper range for best results. Even the groove in the tip is cleaned thoroughly, since the cord, on account of its small diameter and yielding nature, can rub against sides and bottom.

The holding fixture, a casting, slips over the lockrail and under the keyshelf, where on account of its shape it stays without clamping. At the back is a leather-lined chuck for grasping the plug shell; and at the front, facing it, is a centering pin. The plug is pushed forward through the chuck until its tip is stopped by a cup-like depression in the end of the centering pin; then the chuck is closed. Support of the tip in this fashion braces the contact members, protecting them from bending in case of too vigorous rubbing; the pin also holds the loop of cordage between operations and prevents interruptions to cleaning by slipping of the cord over the end of the plug.



Frank Lohmeyer demonstrates the polisher, in whose development he had a considerable part

Simplicity and convenience are two advantages of this method. Needless wear of plugs is avoided, and there is less chance of harming their insulation. Most important of all, the contact surfaces are thoroughly cleaned and so kept fit for their essential duty in establishing telephone connections.

Radio Conference Delegates Visit the Laboratories

THE delegates to the International Radiotelegraph Conference which has been meeting at Washington since October 4, about three hundred in number, visited the Laboratories on the afternoon of October 31, and in the evening attended a demonstration of several recent developments held in the auditorium. Representing more than fifty nations and forty-one companies engaged in communication by radiotelegraph, the members met at the invitation of the United States Government to bring up to date international treaty agreements on radio communications, which at present are in accordance with treaties signed on July 5, 1912, at the International Radiotelegraph Convention held in London. According to Secretary Hoover, elected President of the Con-

ference at the opening meeting, the fundamental purposes "are to arrive at such modifications as may be necessary in existing international treaties as will promote the wider use, reduce the conflicts, and stimulate the further progress of radio in international communications."

After having spent the morning in inspection of operating and test rooms of the Long Lines Department in the Walker-Lispenard Building and of a panel-type dial system office of the New York Telephone Company at the same location, the party went to the New York Telephone Company's building at 140 West Street. There, at a luncheon, the delegates were welcomed on behalf of the Bell System by Mr. Gifford; before and after luncheon they visited several of the distinctive parts of the building.

Then the party came to the Laboratories, where it was divided into groups of ten for a systematic inspection of activities and equipment in the building. The groups started at different points, but all covered the same ground as far as time permitted. To expedite the visit and to prevent confusion, each laboratory and room to be visited was provided with large descriptive placards in French, the official language of the Conference, and also in English. In addition the work being conducted in the various rooms was described briefly by the guides. Due to the efficient manner in which the tours were organized, practically every part of our Laboratories was seen by the delegates, and many expressed surprise at the great diversity in the lines of investigation that compose the development program of the Bell System.

After their rapid but extensive inspection trip the delegates left at the end of the afternoon, to be guests of the American Telephone and Telegraph Company at an informal dinner at the Waldorf Astoria.

From there they returned to the Laboratories at 8:30 to witness the demonstrations in the auditorium. As the guests assembled music was provided by a phonograph connected to a public address system. Then came a short program of motion-pictures synchronized with sound. Immediately following, Dr. Jewett spoke to the delegates briefly, welcoming them from the standpoint of their scientific interests.

At the end of Dr. Jewett's talk H. E. Ives gave a short talk on the principles and apparatus of television. Sending and receiving apparatus had been set up, and were thereupon put into operation. There was no outside connection, but pictures were sent from the transmitting apparatus and were reproduced, both enlarged and reduced in size, by the two sets of receiving apparatus.

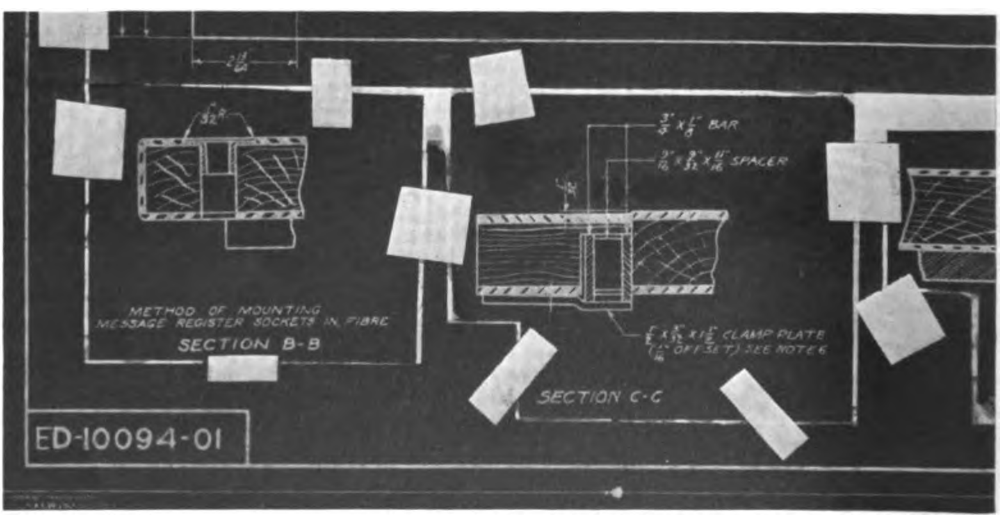
During the television demonstration, connection was made by transatlantic telephone with the London office of the American Telephone and Telegraph Company so that the delegates could converse with guests whom Mr. Shreeve and his associates had invited. There were provided in addition about a dozen receivers, giving an opportunity for more extended listening than any person could make while he was talking over the circuit. Interest in the transatlantic conversations, so directly in line with the interests and scope of the Conference, was enhanced by the morning visit to the Walker-Lispenard Building, where representatives had seen the handling of transatlantic calls by traffic and technical operators.

Saving the Tracing in the Systems Drafting Group

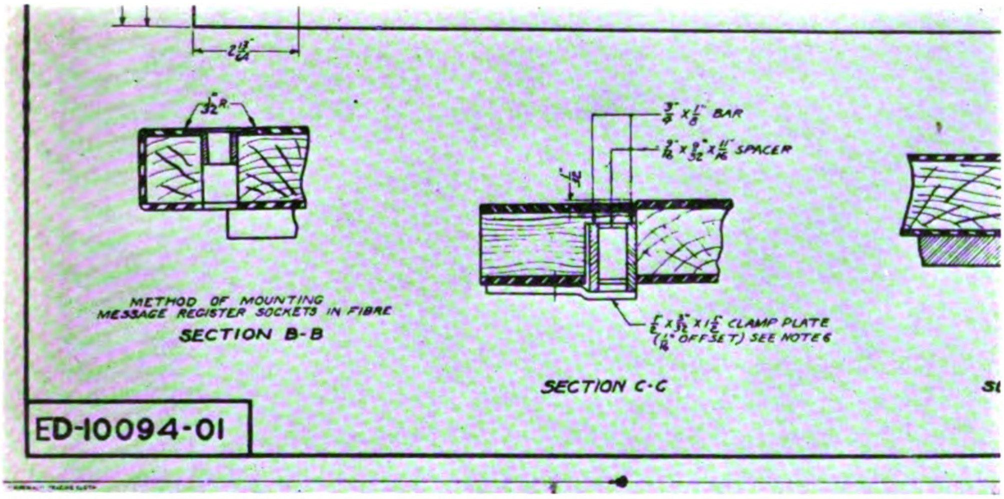
By W. L. HEARD
Systems Development Department

PARADOXICAL as it may sound, most of the tracings used in the Bell System are not tracings. Underlying this anomaly is the fact that usually tracings are very costly things, particularly those of some of the extremely complicated circuit drawings. A single tracing may be valued at as much as four or five hundred dollars. Because of this high cost every effort has been made both to utilize substitutes for the purpose of making blueprints, and to find more economical means of reproducing or making new tracings as they are required. Thus many of those used, instead of being actually hand drawn, are reproduced or built up from the original ones by inexpensive methods.

As a result of this policy, very few prints are made from hand-made tracings. The heating that a tracing undergoes in passing through the blueprint machine dries it and ultimately cracks appear. When a new tracing has been finally approved, a number of vandykes are immediately made from it. These are brown prints on translucent paper which may be used as negatives for blueprinting purposes. Prints made from vandykes have blue lines on a white background and are easy to follow.



Preliminary step in the reproduction of a tracing. Sections of vandykes of different drawings are pasted together in the proper relative positions before being placed on the gelatin



Section of final reproduced tracing made up as shown on the opposite page

Some of the vandykes are left in the vault to be used for making prints and others are sent out to Hawthorne or wherever prints of the drawings will be required. Another advantage of this system is that prints may be made while the original tracing is being changed.

"Prevent deterioration of the tracing," is a guiding imperative of the Systems Drafting room. Not only are vandykes used for making all blueprints but the tracings themselves are handled by no one but the draftsman working on them. Engineers' approvals are obtained from blueprints, furnished specially for this purpose.

While the wear on tracings is considerably reduced by this use of the vandykes, still greater savings are made by the use of reproduced tracings which further cut down the number of hand-made drawings required. These are on regular tracing cloth and by the outsider could readily be mistaken for the more genuine article. Two commercial methods of reproduction, the "See Bee" and the "Litho Print," are used.

The "See Bee" is regular tracing cloth, one side of which has been covered with a sensitized coating which prints black when exposed to light. To make a reproduced tracing of this type, the sensitized cloth, in contact with a vandyke, is passed through the blueprint machine. The tracing is then developed which leaves black lines on the transparent background.

The "Litho Print" is made by a gelatin contact process on regular tracing cloth. A blueprint made from a vandyke is placed, before it is washed, on a special gelatin plate. The lines on the print, which have been exposed to light, etch into the gelatin. When the print is removed the gelatin is rubbed with a special ink which adheres only to the lines. The plate, being impressed on tracing-cloth, leaves an imprint which is equivalent to the original tracing.

One of the principal savings due to these methods of reproducing comes not from making duplicate tracings but from building up new ones from sections of other drawings with new material added. It may be necessary to make a number of minor changes or additions, such as add-

ing coin-collecting features to standard circuit drawings. To make completely new tracings would be an enormous waste of time as perhaps on a large and intricate drawing only a few additional lines or notes need be supplied.

The method used is to cut from a vandyke of the existing drawing those parts that will be used on the new one. These may be rearranged if desired; and they are then placed on the gelatin in their proper position. From this a reproduced tracing is made which may then be finished by hand by the addition in ink of the necessary circuits or equipment. Also typewritten notes may, by a similar operation, be incorporated in the reproduced tracing serving to make it more applicable to the specific purpose for which it is to be used.

So flexible is the method that there is almost no end to its possible applications. Scarcely a drawing is made that will not have on it some circuits that have appeared on previous tracings. Whether they are drawn in anew or added by one of the reproduction methods is merely a question of balancing the time required to draw them against the small cost of the mechanical reproduction which for an entire drawing is only from eight to ten dollars. Some idea of the savings possible may be gained when it is realized that just the use of the vandykes and approval prints with Systems drawing is paying dividends of almost twenty thousand dollars a year due to the decreased wear on tracings.

Telephone Service Opened with Mexico

TELEPHONE service between the United States and Mexico was inaugurated on September twenty-ninth by distinguished gatherings in New York, Washington and Mexico City. Conversations were held between President Coolidge and President Calles, and between other prominent guests.

In the course of his comments, President Coolidge remarked: "Conspicuous among the accomplishments of the present age is the extraordinary development of means for facilitating communication between the nations of the world. . . . We owe a debt of gratitude to the engineering skill and public spirit on both sides of the boundary which has made possible the new link between Mexico and the United States."

More immediately applicable than he perhaps suspected, these remarks of President Coolidge were made of unique timeliness by the disastrous windstorm which centered its destruction in St. Louis a few hours before the scheduled conversation. During the preceding week men of the Long Lines Department and of associated companies had been busy day and night fitting together the various parts making up two lines between Washington and Mexico City. Because of its unusual importance, the opening had been doubly safe-



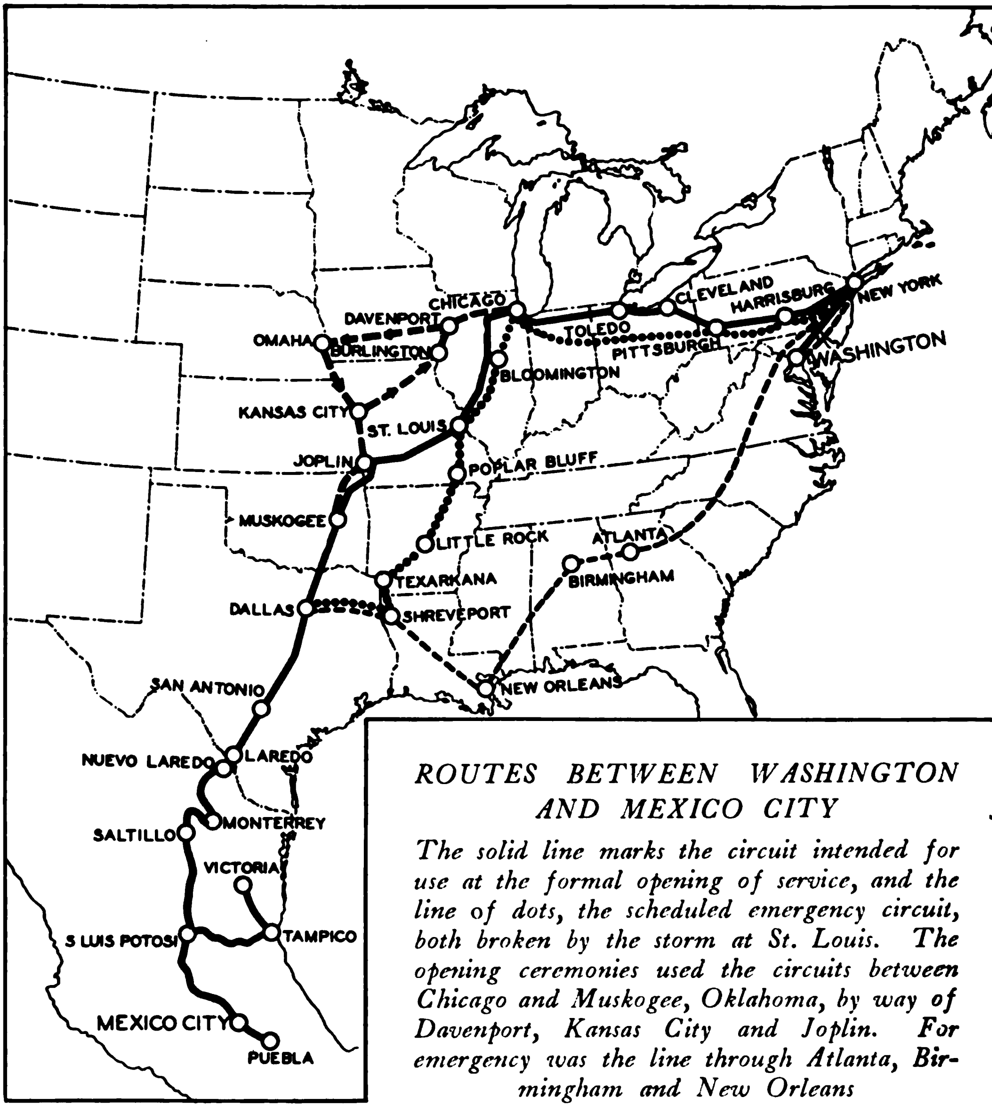
Guests of honor at the ceremonies in Washington: Mr. Gifford; Dr. L. S. Rowe, Director General of the Pan-American Union; Don Manuel C. Tellez, Ambassador from Mexico; President Coolidge; Wilbur J. Carr, Acting Secretary of State; Henry B. Orde, Vice-President International Tel. and Tel.; T. G. Miller, General Manager, Long Lines Department

guarded. Extra forces of linemen patrolled the lines at various points. Every man assigned to any part of the service in Washington, New York, Mexico City and the fifty repeater stations between knew his duties thoroughly. At the beginning of the afternoon, when the "dress rehearsal" took place, all parts worked perfectly, on the emergency circuit as well as on that scheduled for use. It seemed that everything was in readiness for service of the highest order from the start.

Then came a brief rest for lunch —and the St. Louis tornado! Both circuits were broken, and from news received by telegraph it was apparent that they could not be restored in time for the demonstration which was scheduled to take place within three and one half hours.

There was no time to be wasted. Within fifteen minutes other routes were being chosen, and plans for the emergency were being prepared. More than two hundred men leaped to the job of building up anew a regular circuit and an emergency circuit from Washington to Texas. Chicago was asked to get through to Muskogee, which was on the original route, via Kansas City; to New York was delegated the work of connecting a circuit through Washington to Atlanta, Birmingham, New Orleans, Alexandria and then to Shreeveport, where is was connected to the original emergency circuit.

Through this latter circuit was established at four o'clock the first contact with Mexico City following the break. Meanwhile the Chicago test room had succeeded in getting



ROUTES BETWEEN WASHINGTON AND MEXICO CITY

The solid line marks the circuit intended for use at the formal opening of service, and the line of dots, the scheduled emergency circuit, both broken by the storm at St. Louis. The opening ceremonies used the circuits between Chicago and Muskogee, Oklahoma, by way of Davenport, Kansas City and Joplin. For emergency was the line through Atlanta, Birmingham and New Orleans

a circuit—the one over which President Coolidge and President Calles spoke—through Davenport, Omaha, Kansas City and Joplin to Muskogee. Both circuits were ready by the hour announced for the demonstration. Since the great speed had prevented adequate testing of any of the circuits, two other routes were set up as an extra precaution, but were not needed.

" . . . extraordinary development of means for facilitating communication between the nations of the world. . . ."

The President indeed spoke for all who hear even in part the story of such a victory.

News of the Month

Charles G. DuBois has resigned from the Board of Directors of Bell Telephone Laboratories. In accepting his resignation as of September 30, the Board resolved " . . . that in accepting the resignation the board express to Mr. DuBois its deep feeling of regret at the loss to them and to the company of the wise counsel and advice of one who, as an organizer of the company and a director continuously from the beginning, had done so much to make Bell Telephone Laboratories, Incorporated, a success."

* * *

Mr. Jewett and Mr. Craft were present in Washington at the official opening of telephone service to Mexico on September 29.

* * *

S. P. Grace addressed the convention of the United States Independent Telephone Association on October 20 in Chicago, on some recent developments of the Laboratories. Assisted by V. A. Schlenker and L. W. Davee, he demonstrated how speech, made unintelligible by frequency-inversion, can be understood when a second inversion is made.

Research Department

E. M. Noll spent September 28 to 30 at Providence, Rhode Island, inspecting a compression testing machine for rubber, being built for the Laboratories by the Henry L. Scott Machine Company.

A. R. Kemp and C. S. Gordon were in Boston on September 22, visiting the Boston Woven Hose and Rubber Company and the Simplex Company in connection with work on friction tape and rubber covered wire.

J. W. Horton attended a special advisory committee on September 16 at Washington, D. C., the function of which was to prepare a report on Methods of Frequency Measurements for the International Radiotelegraph Conference.

W. Wilson, C. R. Englund, H. T. Friis, J. W. Horton and W. A. Marrison attended the meeting of the International Union of Scientific Radio Telegraphy (U.R.S.I.) held at the National Academy of Science Building at Washington, D. C., the week of October 10. J. W. Horton and W. A. Marrison presented a joint paper at the meeting on "Precision Determination of Frequency".

T. C. Fry attended a joint meeting of the American Mathematical Society, Mathematical Association of America and American Astronomical Society held in Madison, Wisconsin, September 6 to 9.

H. A. Frederick and D. G. Blattner made their regular bimonthly visit to the Victor Talking Machine Company at Camden, New Jersey, on September 22.

J. W. Horton and H. M. Stoller presented papers on television before a meeting of the Pittsburgh section of the A.I.E.E. held on October 11.

C. F. Keller visited Hawthorne the latter part of September in connection with the howler test set.

A. W. Hayes, J. T. L. Brown and H. C. Pauly recently visited Hawthorne, being interested in handsets,

testing machines and deaf sets respectively.

W. G. Breivogel recently visited the Western Electric distributing house shops in Boston and Philadelphia in connection with the handset job.

S. T. Acker recently returned from a two weeks' stay at Hawthorne where he had investigated corrosion testing of duralumin for use in the stretched diaphragms of microphone transmitters.

F. F. Farnsworth and A. G. Russell went to Hawthorne on October 6, being interested in the gold plating of transmitter parts.

The Colloquium resumed its meetings on October 10, when W. A. Shewhart spoke on "The Analysis of Small Numbers of Observation".

F. F. Lucas returned to the Laboratories early in October, after having addressed the International Congress for Testing Materials on September 13, at Amsterdam, Holland. According to Iron Age, Mr. Lucas' paper on high-power metallography was "undoubtedly the most interesting paper of the Congress. . . . On all hands it was admitted that a new impetus will have been given to the study of metallography by the developments worked out by Mr. Lucas."

H. F. Hopkins installed and operated an electric stethoscope connected to a public address system, used at a joint meeting of the Queensboro Tuberculosis and Health Association and the Medical Society of Queens, held September 27.

Apparatus Development Department

H. B. Arnold is at Camden, New Jersey, working with the Sub-Committee on Inductive Interference, Project No. 9 of the National Electric Light Association in a study of interference between power circuits and telephone lines at carrier frequencies. For this purpose special power and telephone circuits have been contructed.

Outside Plant Development Department

On October 10, L. V. Lodge was in Torrington, Connecticut, studying timber preservation problems.

C. D. Hocker was in Key West, Florida, during October studying weathering of galvanized samples in connection with committee work of the American Society for Testing Materials.

W. H. S. Youry and O. B. Cooke were in Asbury Park during October conducting tests on guy anchors.

During the second week in October, C. S. Gordon was in Chicago for development work on drop wire attachments.

Systems Development Department

I. G. Wilson and E. Vroom visited Batavia, New York, to observe tests being made in connection with 21-A repeater development.

The first shop-made D-1 repeaters were tested at Hawthorne by A. C. Dickieson and F. H. Chase.

K. M. Fetzer carried on several tests at Syracuse and Watertown on the D-1 carrier installation, which has been in service for several months.

A. E. Bachelet and R. A. Le Conte visited the repeater stations at Pittsburgh, Bedford and Ligonier in connection with experiments which have been in progress between Pittsburgh and New York, directed to-

ward use of cables for broadcasting circuits.

F. B. ANDERSON has been carrying on tests at Reading, Pennsylvania, on improved testing arrangements for repeater stations.

G. R. VERNON is making tests on the new two-hundred point line finders which are being installed in the new step-by-step office at Utica, New York.

P. T. SLATTERY visited Hartford, Connecticut, and Scranton, Pennsylvania, in connection with studies on step-by-step equipment.

W. J. LACERTE observed operation of the new cordless B switchboard at McKeesport, Pennsylvania.

J. R. STONE visited the General Electric Company's factory at Fort Wayne, Indiana.

G. C. CUMMINGS visited the new Cleveland toll office, to inspect several new features of the telegraph equipment. R. G. Koontz and G. A. Benson also visited the Cleveland office during the month.

ON ACCOUNT OF the large addition to be made to the Chicago toll office and changes in the present toll switchboard occasioned by change to the C. L. R. method of operation, J. W. Woodward went to Chicago for discussion of the project with the Telephone Company's engineers.

H. T. LANGABEER and V. T. CALLAHAN were at Buffalo, making tests on gas engines to be used for emergency power.

G. F. SCHULZE and E. H. SMITH spent a week at Hawthorne.

P. B. MURPHY, addressing the Men's Club of Nyack on September 26, described some developments of the Laboratories and presented the moving picture film, "The Magic of Communication".

INSPECTION ENGINEERING DEPARTMENT

DURING THE PAST MONTH, S. H. Anderson, W. A. Boyd, H. F. Kortheuer, W. C. Miller and A. Grendon were at Hawthorne for regular Inspection Survey Conferences.

D. A. QUARLES and S. H. Anderson were at the Fort Wayne factory of the General Electric Company during the week of September 19 for a Survey Conference on fractional horsepower motors.

ON OCTOBER 10, W. C. Miller and A. Grendon visited the factory of the Morkrum-Kleinschmidt Corporation in Chicago.

DURING THE WEEK of September 19, R. B. Miller was in Philadelphia in connection with the trial of a sampling plan for use in the inspection of newly installed central office equipment.

J. M. SCHAEFER, Local Field Engineer at Omaha, visited Helena, Montana, and Denver, Colorado, recently in connection with regular field work in his Territory.

PATENT

G. M. CAMPBELL, J. A. Hall, M. R. McKenney, G. T. Morris, G. H. Stevenson and W. B. Wells visited Washington during September and the early part of October in connection with the prosecution of applications for patents.

DURING JUNE, JULY, AUGUST and SEPTEMBER patents were issued to the following members of the Laboratories staff:

J. H. Bell
A. S. Bertels
N. Blount
H. Boving
J. T. L. Brown
W. W. Carpenter
E. H. Clark
R. E. Coram
L. T. Cox
S. T. Curran
A. M. Curtis (5)
G. W. Elmen
J. F. Farrington
J. G. Ferguson

C. B. Fowler (2)
J. C. Gabriel
J. O. Gargan (2)
E. W. Gent
F. H. Graham
A. Haddock (2)
A. E. Hague
L. N. Hampton (2)
R. V. L. Hartley (3)
H. C. Harrison (2)
R. A. Heising
E. E. Hinrichsen
C. D. Hocker (2)
J. W. Horton (5)
W. G. Houskeeper (5)
F. A. Hubbard (2)
H. E. Ives
H. B. Johnson (2)
J. B. Johnson
L. H. Johnson
W. C. Jones (2)
L. W. Kelsay
A. R. Kemp
W. C. Kiesel
G. R. Lum
R. C. Mathes (2)
E. C. Mueller (2)
W. A. Marrison
D. D. Miller
F. Mohr
E. L. Nelson
R. Nordenswan
E. L. Norton
H. W. O'Neill (2)
A. A. Oswald
L. F. Porter (2)
L. M. Potts
C. D. Richard
V. L. Ronci (3)
J. C. Schelleng (2)
T. E. Shea (2)
G. O. Smith
H. M. Stoller
H. S. Taylor
F. A. Voos
E. Vroom
G. P. Wennemer
E. C. Wente
E. B. Wheeler (2)
D. F. Whiting
W. Whitney
J. M. Wilson

GENERAL STAFF DEPARTMENT

W. C. F. FARNELL was a delegate of Edward J. Hall Chapter of the Telephone Pioneers of America at the annual Pioneers convention, held September 20 and 21 at Colorado Springs. Mr. Farnell went and returned on a special train carrying Pioneers from New York and New England.

A CONFERENCE of those who represent the Bell System in its relations with educational institutions was held at Hawthorne September 22 to 30. From the Laboratories were G. B. Thomas, M. B. Long and John Mills. One session of the conference was addressed by President Jewett.

THE ELECTRICAL STETHOSCOPE was explained and demonstrated to the Flushing Forum on September 26 by Paul B. Findley of the Bureau of Publication.

Bell Laboratories Club

Golf

AFTER many rainy week-ends, the weather man presented our golfers with perfect weather for the tournament held at Salisbury Country Club on Saturdays, September 17 and 24. Sixty golfers teed off in the qualifying round of the Club's fifth tournament on the seventeenth, and turned in scores indicating that considerable time had been given to practice. Winners of the two prizes for low gross scores in the qualifying round were J. Hillier, 82, and O. Cesareo, 87; Mr. Hillier's score is the lowest at any of the Club tournaments. The two prizes for low net score were won by E. C. Mueller, 66, and E. Peterson, 67.

The thirty players qualifying for the finals were:

J. Hillier	J. C. Kennelty
E. H. Clark	J. B. Retallack
O. Cesareo	M. R. McKenney
H. W. Wood	A. F. Kane
S. J. Lambert	L. N. Hampton
R. J. Nossaman	J. V. Moran
N. H. Thorn	E. J. Canavan
A. L. Johnsrud	W. H. Clarkson
G. W. Haglund	W. F. Johnson
L. G. Hoyt	H. L. Downing
G. E. Kellogg	G. H. Heydt
A. A. Reading	C. H. Achenbach
E. C. Mueller	A. F. Price
E. Peterson	D. A. Quarles
W. H. Harvey	A. W. Lawrence

All those who qualified participated in the finals, and in addition some of the other golfers played September 24. Scores were exceptionally good. The players had been divided into two classes on the basis of their scores in the qualifying round; four prizes were awarded in each group, and in addition a prize was given to the player with low gross score for 36 holes. The winners were as follows:

Class A

Low Gross Score—H. W. Wood	84
Low Net Score—R. J. Nossaman	69
Second Low Net Score—G. W. Haglund	73
Third Low Net Score—A. A. Reading	73

Class B

Low Gross Score—A. W. Lawrence	92
Low Net Score—W. H. Harvey	69
Second Low Net Score—J. V. Moran	69
Third Low Net Score—J. C. Kennelty	70
Low Net Score for 36 Holes—E. C. Mueller	139

Bowling

The Bowling League opened the 1927-28 season on Friday evening, September 30, at Dwyer's Bowling Alleys, 1680 Broadway. The Bowling Committee received entries from one hundred and fifty men wishing to bowl as regulars, and to accomodate such a large number organized an additional group, D. The Club will use twenty-eight alleys each week, for a twenty-eight week season.

In addition names of about a hundred men were received who wished to bowl as substitutes. The substitute Committee is always glad to hear from men who desire to bowl irregularly. Such men may have their names placed on the substitute list by communicating with C. W. Lowe, Chairman of the Substitute Committee.

All league games will start promptly at 5:45. The charge for each evening's bowling is one dollar and ten cents per man.

Hiking

The Hiking Club's November schedule appears on the following pages. Those interested can obtain further information from Phyllis Barton.

Bell Laboratories Club

TUESDAY, 1: *Basketball, Men, Labor Temple, 5:30 p.m.*
Symphony Orchestra Rehearsal, Auditorium, 6 p.m.
Women's Bridge Club, Rest Room, 5:15 p.m.

WEDNESDAY, 2: *Women's Swimming Class, Carroll Club, 5:30 p.m.*

THURSDAY, 3: *Basketball, Men, Labor Temple, 5:30 p.m.*

FRIDAY, 4: *Bowling League, Dwyers Manhattan Alleys, 5:45 p.m.*
Athletic Dancing Class, Women, Louis Vecchio's Studio, 5:30 p.m.

SATURDAY, 5: *Horseback Riding, Unity Riding Academy*
Chess, Commercial Chess League Tournament

MONDAY, 7: *Men's Bridge Club, Room 273, 6 p.m.*
Basketball, Women, Manhattan Trade School, 5:30 p.m.
Women's Swimming Class, Carroll Club, 7 p.m.

TUESDAY, 8: *Hike, Grassy Sprain Reservoir*

WEDNESDAY, 9: *Women's Swimming Class, Carroll Club, 5:30 p.m.*
Basketball, Men, Bell System League Tournament Stuyvesant High School, 7:30 p.m. Dancing after the game.

THURSDAY, 10: *Basketball, Men, Labor Temple, 5:30 p.m.*

FRIDAY, 11: *Bowling League, Dwyers Manhattan Alleys, 5:45 p.m.*
Athletic Dancing Class, Women, Louis Vecchio's Studio, 5:30 p.m.

SATURDAY, 12: *Horseback Riding, Unity Riding Academy*

MONDAY, 14: *Men's Bridge Club, Room 273, 6 p.m.*
Basketball, Women, Manhattan Trade School, 5:30 p.m.
Women's Swimming Class, Carroll Club, 7 p.m.
Basketball, Men, Bell System League Tournament, Stuyvesant High School, 8:30 p.m. Dancing after the game.

TUESDAY, 15: *Basketball, Men, Labor Temple, 5:30 p.m.*
Symphony Orchestra Rehearsal, Auditorium, 6 p.m.
Women's Bridge Club, Rest Room, 5:15 p.m.

Calendar for November, 1927

WEDNESDAY, 16: *Women's Swimming Class, Carroll Club, 5:30 p.m.*

THURSDAY, 17: *Basketball, Men, Labor Temple, 5:30 p.m.*

FRIDAY, 18: *Bowling League, Dwyers Manhattan Alleys, 5:45 p.m.*
Athletic Dancing Class, Women, Louis Vecchio's Studio, 5:30 p.m.

SATURDAY, 19: *Hike, Hunter Island*
Riding, Unity Riding Academy
Chess, Commercial Chess League Tournament

MONDAY, 21: *Men's Bridge Club, Room, 273, 6 p.m.*
Basketball, Women, Manhattan Trade School, 5:30 p.m.
Women's Swimming Class, Carroll Club, 7 p.m.

TUESDAY, 22: *Basketball, Men, Labor Temple, 5:30 p.m.*
Symphony Orchestra Rehearsal, Auditorium, 5:35 p.m.
Women's Bridge Club, Rest Room, 5:15 p.m.

WEDNESDAY, 23: *Women's Swimming Class, Carroll Club, 5:30 p.m.*

FRIDAY, 25: *Bowling League, Dwyers Manhattan Alleys, 5:45 p.m.*
Athletic Dancing Class, Women, Louis Vecchio's Studio, 5:30 p.m.

SATURDAY, 26: *Riding, Unity Riding Academy*

SUNDAY, 27: *Hike, Midvale to Suffern*

MONDAY, 28: *Men's Bridge Club, Room 273, 6 p.m.*
Basketball, Men, Stuyvesant High School, 7:30 p.m.
Basketball, Women, Manhattan Trade School, 5:30 p.m.
Women's Swimming Class, Carroll Club, 7 p.m.

TUESDAY, 29: *Basketball, Men, Labor Temple, 5:30 p.m.*
Symphony Orchestra Rehearsal, Auditorium, 5:35 p.m.
Women's Bridge Club, Rest Room, 5:15 p.m.

WEDNESDAY, 30: *Women's Swimming Class, Carroll Club, 5:30 p.m.*

Tuesday, November eighth, election day, the group will walk from Van Cortlandt Park to Grassy Sprain Reservoir, a distance of eight miles over dirt roads.

Saturday, November nineteenth, they will start from the entrance to the new building and go to Hunter Island. This is to be a short hike, over trails and dirt roads, and leads to a very attractive spot.

Sunday, November twenty-seventh, the hike will be more strenuous. It will lead from Midvale to Suffern, over fourteen miles of trails and cross country roads in the Ramapo Mountains.

Glee Club

With a professional instructor and an interested crowd, there should be many enjoyable evenings at the new Glee Club. D. D. Haggerty and Ada Van Riper will be glad to give information to all who want it.

Photographic Contest

Now is a good time for camera users to busy themselves in preparation for this year's photographic contest, to be announced later.

Christmas Poster Contest

There is to be a contest this year open to everybody. Those gifted with the ability to design and make posters are asked to send in their entries by December first. All posters should be twelve by sixteen inches, in not more than three colors and with space left for a Christmas Greeting which will be inserted after the winning entry has been chosen. The posters will be judged by an impartial committee, and one or more of the best will be reproduced and displayed on the bulletin boards.

Men's Bridge Club

The men's bridge club held the first meeting on Monday evening, October 10 at 6 P. M., in Rooms 273 and 275. Its tournament will extend over a period of ten weeks with meetings every Monday evening at the same time and place. Each player taking part is charged fifty cents weekly. L. P. Collins, section 6D, extension 563, is always glad to welcome bridge players who wish to take part in the activities of the club.

Women's Club Activities

Swimming. Those near the pool of the Carroll Club any Monday or Wednesday night can tell from Miss Steil's whistle that the Laboratories Club Class has started. There are thirty-three in the Wednesday class and twenty-six on Monday. The potential swimmers are divided into groups according to ability, and receive instruction within the groups. Watching a first dive or a swimmer float across the pool for the first time brings as much of a thrill to observers as to the swimmer. Everyone is showing progress even at this early date under the new plan.

Dancing. Twenty-five members arrived at Mr. Vecchio's studio on October fourteenth for the year's first lesson of the dancing class. All were pleased to see that the studio is larger, and that indications pointed to most interesting work this year.

Basket-ball. There is not much news yet about the Women's Basket Ball Team, except that they are practicing for games later in the season.

Bridge. The first game of the season for women was played on Tuesday, October fourth, in the Rest Room, with twenty-four players present. Since then these bridge enthusiasts have been playing each Tuesday night. Katherine Munn will appreciate it if those wishing to play will let her know by Monday.

BELL LABORATORIES RECORD

A STATEMENT OF POLICY

CENTRAL OFFICE GENERATORS

STRENGTH TESTS OF TELEPHONE MATERIALS

CLUB ELECTIONS

DECEMBER 1927 VOL. 5 NO. 4

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Bell Laboratories Record

Volume Five DECEMBER, 1927 *Number Four*

A Statement of Policy

By WALTER S. GIFFORD

President, American Telephone and Telegraph Company

Before the National Association of Railroad and Utilities Commissioners

BROADLY considered, you as Public Utility Commissioners and we in the telephone business, are engaged in a common enterprise; our success must depend upon mutual confidence and understanding. In the current performance of our daily tasks it is possible to lose sight of the ultimate aim and goal of our endeavors. With the thought in mind that it may prove helpful, I wish to state very briefly the principles that guide the management of the Bell System.

There are today over 420,000 stockholders of the American Telephone and Telegraph Company and no one of them owns as much as one per cent of the capital stock. The business of this Company and its Associated Bell Telephone Companies, whose common stock is largely owned by this Company, is to furnish telephone service to the nation. This business from its very nature is carried on without competition in the usual sense.

These facts have a most important bearing on the policy that must be followed by the management if it lives up to its responsibilities. The fact that the ownership is so widespread and diffused imposes an unusual obligation on the management to see to it that the savings of these hundreds of thousands of people are secure and remain so. The fact that the responsibility for such a large part of the entire telephone service of the country rests solely upon this Company and its Associated Companies also imposes on the management an unusual obligation to the public to see to it that the service shall at all times be adequate, dependable and satisfactory to the user. Obviously, the only sound policy that will meet these obligations is to continue to furnish the best possible telephone service at the lowest cost consistent with financial safety. This policy is bound to succeed in the long run and there is no justification for acting otherwise than for the long run.

It follows that there is not only no incentive but it would be contrary to sound policy for the management to earn speculative or large profits

for distribution as "melons" or extra dividends. On the other hand, payments to stockholders limited to reasonable regular dividends with their right, as the business requires new money from time to time, to make further investments on favorable terms, are to the interest both of the telephone users and of the stockholders.

Earnings must be sufficient to assure the best possible telephone service at all times and to assure the continued financial integrity of the business. Earnings that are less than adequate must result in telephone service that is something less than the best possible. Earnings in excess of these requirements must either be spent for the enlargement and improvement of the service furnished or the rates charged for the service must be reduced. This is fundamental in the policy of the management.

The margin of safety in earnings is only a small percentage of the rate charged for service, but that we may carry out our ideals and aims it is essential that this margin be kept adequate. Cutting it too close can only result in the long run in deterioration of service while the temporary financial benefit to the telephone user would be practically negligible.

Our policy and purpose are the same as yours—the most telephone service and the best, at the least cost to the public. Without overlooking the fact that we lack the big money incentive for maximum profits and the drive for improvement that results from active and strong competition, we believe the telephone company is organized to make continuous and effective progress.

Professor Cabot of the Harvard Business School made the following comment on the Bell System: *"The thing is a modern miracle which I can only explain to myself by assuming that the men who conceived, created and have developed the telephone were men of the rare automotive type whose driving power came from within, and who, therefore, did not need the external stimulation which competition alone can give."*

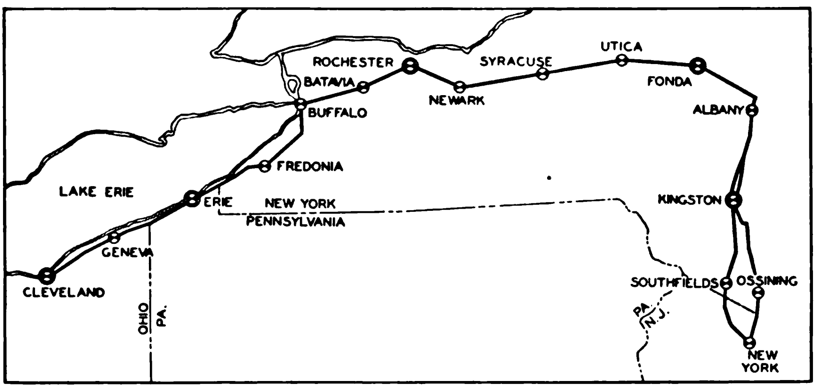
Undoubtedly a very great factor in the continued progress and improvement of telephone service is the intangible but quite real spirit of service that has become a tradition in the telephone business, but the results of the Bell telephone business have a broader foundation than the one Professor Cabot has recognized. It is fundamental in our plan of organization to have at headquarters and in our laboratories several thousand people whose sole job it is to work for improvement. They are engaged in studying what is used in the telephone business and how it is used and endeavor to find a better thing or a better way. Of course, the people who are engaged day by day in trying to maintain a high standard of telephone service are doing their part, and a most important part, in increasing the quality and keeping down the cost of service, but progress is assured by having a large group of scientists and experts devoted exclusively to seeking ways and means of making the service better and cheaper.

It is now nearly 20 years since the State Commissions generally took over the duties of regulating the telephone companies. During those 20 years the physical results of your regulation and our operation are impressive. In 1907 there were about 6,000,000 telephones in the United

States but they were only partially interconnected, while today there are over 18,000,000 telephones in the United States so interconnected that it is possible for practically any one of the 18,000,000 to be connected with reasonable promptness with any other one of the 18,000,000. Thus today, practically any one anywhere can talk by telephone with any one else, anywhere else in the country. Moreover, any one in the United States can now converse by telephone with any one in Great Britain, Canada, Cuba and the principal cities of Mexico. This is real progress in extent and facility of communication, but we realize we are still far from our ultimate goal.

With your sympathetic understanding we shall continue to go forward, providing a telephone service for the nation more and more free from imperfections, errors or delays, and always at a cost as low as is consistent with financial safety.

New York-Cleveland Cable Completed



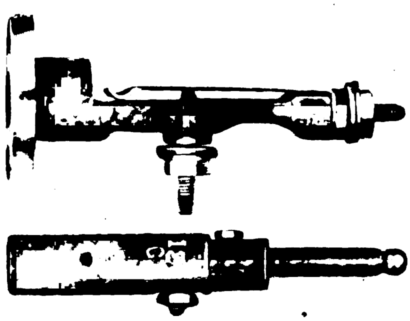
The first billion-dollar mark in Bell System plant investment took forty-one years to reach. Another billion was added in six years, while the third billion-mark was passed some time last August, less than four years later. Of these huge sums and of the $270,000,000 *which will have been expended for net additions to plant during* 1927, *a large part has been invested in equipment developed in Bell Telephone Laboratories.*

For example, lead-antimony cable sheath, permalloy - and iron-dust cores for loading coils, vacuum tubes and their associated circuits, and the metallic morse system are outstanding elements of the recently completed New York-Cleveland toll cable project. This cable will provide facilities for more than 250 *telephone conversations and* 500 *telegraph messages.*

Fifty Years of Telephone Plugs

By PAUL NEILL
Apparatus Development Department

On the first commercial telephone switchboard, installed in New Haven in January, 1878, the connections between subscribers were made by means of crude switches consisting of pivoted metal strips fitted with hard rubber handles. These made contact with metal buttons screwed into the wood from which the switchboard was made. In certain other switchboards built about the same time, each line, which used only a single wire with ground return, was terminated on a metal bar. Between these, contact was made by insertion of brass pegs such as are used extensively in railroad telegraphy and in some forms of Wheatstone bridge.



Warner jack and plug, brought out in 1882

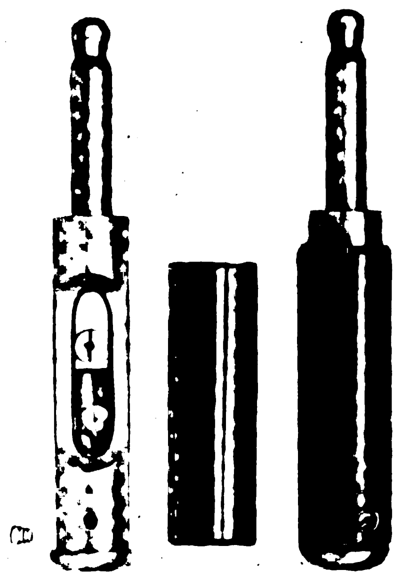
Though switchboards were made less bulky by use of peg-type plugs, the growing demand for telephone service showed that other lines of development must be followed to attain greater flexibility and compactness. Consequently in the fall of that same year Charles Williams of Boston built a switchboard employing pairs of plugs connected by cords. In these, the first telephone plugs with attached cords used commercially, there was a single conductor, adequate for the simple circuits of that time.

In 1882 came an approach to present apparatus, the plug and jack developed by J. C. Warner in Chicago, and used in the "Standard" Western Electric switchboard which was produced that year. The plug was made with rounded tip contact and cylindrical sleeve, separated by a tube of insulation; connections to the cord were made externally, on opposite sides. Though crude when judged by today's standard, this plug marked a direct and most prominent step toward those now in use.

Changes in switchboard design followed each other in close succession to take care of the rapidly growing list of subscribers and the steadily increasing traffic. With the changes came need for improvement in plugs and jacks, and reduction in size so that they could be placed closer together. The individually-mounted jacks were decreased in size, and then were supplanted to a large extent by jacks mounted in strips; by this means the space needed for the mounting was greatly reduced. At the same time the plugs were made smaller, and the connections were made inside the shells. Thus the ends of the

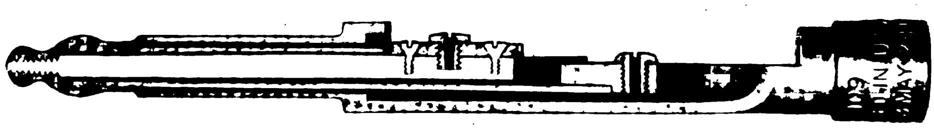
conductors were protected, making it possible to place the jacks much closer together.

With the development of metallic circuits, a third contact member in the plug became necessary to take care of the three conductor multiple. Accordingly a three-contact plug—No. 37—was brought out about 1891. The contact members were tip, ring, and sleeve as at present, but the profile was considerably different from that of today, since ring and sleeve were of the same diameter. The ring contact surface was separated from tip and sleeve only by narrow collars of hard rubber. This plug was followed by several others of approximately the same shape and general design. About 1897 came the No. 49 jack, and with it a new plug, No. 64. Between tip and ring was a wide insulator of hard rubber, having the same diameter as the sleeve; the diameter of the ring was less, about the same as that of the tip. This plug, whose profile showed the direction which development would take, gave good results electrically, but wear on the insulating collar was excessive, and there were other mechanical difficulties. This plug was very shortly superseded by the No. 104, in which the broad rubber collar was replaced by a band of brass insulated from other parts of the plug, termed the "dead collar". This band acts as a spacer between tip and ring, preventing them from touching simultaneously the ring contact spring or the sleeve of the jack during insertion or withdrawal. About 1905 the No. 104 plug was



The No. 47 plug, used for test boards, magneto switchboards and private branch exchanges

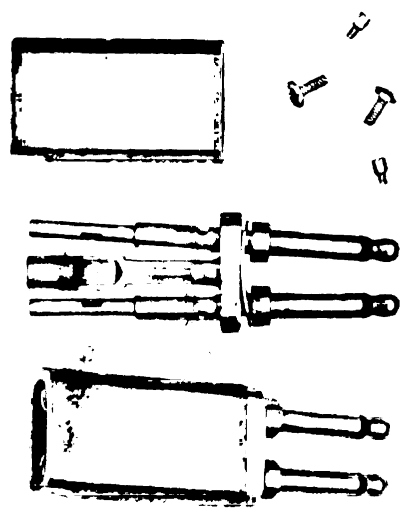
replaced by the present No. 110, which is similar in general design but is marked by several changes in profile. One point of improvement, whereby the tip and ring of the plug were more effectively prevented from coming into contact with the sleeve



Sectional view of the No. 109 plug, enlarged by two thirds

of the jack, was use of a dead collar with flat top in place of the collar with rounded outer surface which had been used on No. 104 plug.

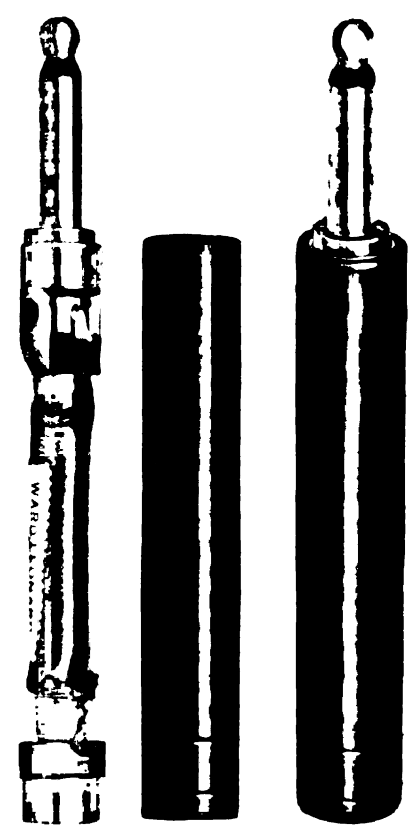
During these developments, in-



Twin plug used at toll test boards

crease in the number of telephone subscribers and growth of telephone traffic had continued rapidly, necessitating further compactness of telephone facilities. The size of jacks and plugs was an important factor in limiting the number of lines which could be terminated within reach of an operator. The minimum spacing for No. 49 jacks, both vertical and horizontal, is 7/16 inch, and so to meet the demand for economy of space, No. 92 jacks, which are spaced 3/8 inch apart, were brought out in 1901. By their use in the multiple of B-switchboards as many as ten thousand five hundred lines are terminated within reach of a single operator. With this jack came a corresponding plug, the No. 101, similar to the larger No. 104 design; it was replaced about 1904 by the No. 109, which remains the smallest standard Western Electric plug made with three conductors. Approximately four hundred thousand of these plugs are made each year, and almost as many of the No. 110; there are probably a million of each of these models in service throughout the country.

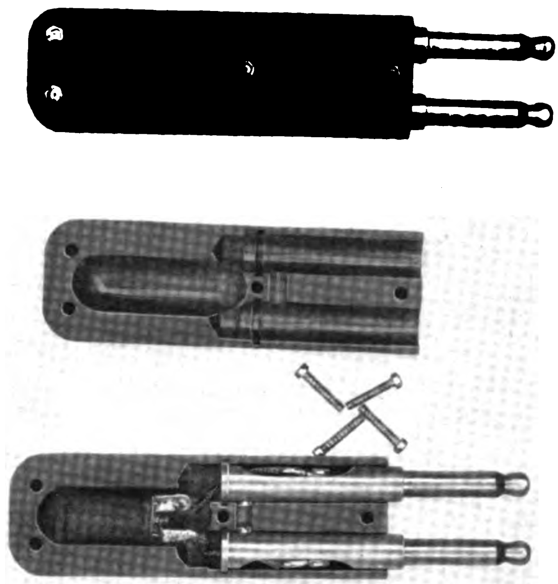
The construction of these two currently-used plugs is almost the same except for size. On each, connection of the cord tip and ring is made with small button-head binding screws inside the shell. Connection to the sleeve is made by folding the bare



Plug with resistance unit for use in telegraph circuits

end of the sleeve conductor back over the cord insulation. Then when the cord is screwed into the open threaded end of the sleeve, the exposed conductor is wedged against the inner threads, and makes contact with them. In addition the outer braid of the cord is held by these threads, so that the strain is borne by the outer braid rather than by the conductors. Essentially these plugs are made up of concentric tubes, alternately of metal and of insulation. The principal member, outermost, is of brass; at one end it forms the sleeve contact, and at the other the body, around which the shell is placed. Directly inside is a tubular insulator, with a flange at the end to form a spacer between sleeve and ring. Inside this insulator is a thin brass tube, bearing at one end a flange which forms the ring contact and at the other end a short brass rod, semicircular in cross-section, to which the ring conductor of the cord is fastened by a binding screw. Enclosed in the ring tube is another insulating tube, and inside that is a steel rod which forms the center and backbone of the plug. To the outer end of the rod the tip contact is screwed, and at the other end is fastened a connection plate to which the tip conductor of the cord is fastened. The dead collar, made of an alloy chosen for its wearing qualities, is placed between tip and ring; it is separated from them by insulating washers, and from the plug center by the inner insulating tube. The tubular shell by which an operator grasps the plug is of fibre, fastened to the main body by a small screw. Handling of these shell screws, and the binding screws as well, is facilitated by a small hole at the center of each, which fits the tapered prong of a special screwdriver.

Although by far the greater part of the plugs made each year are No. 109 or No. 110, there are many others used for various purposes. Most common of these is the No. 47,



Twin plug with resistance unit, for balancing toll circuits during testing

of which about 60,000 are made annually. It is used principally for private branch exchanges, magneto switchboards and test boards. The sleeve is a quarter inch in diameter, and the tip, pear-shaped, is slightly smaller.

In addition there are a number of "twin" plugs, essentially two plugs

mounted in a single shell or handle. Twin plugs now in general use have their "fingers" mounted flexibly to permit them to align themselves readily with jacks whose spacing varies somewhat. In most of the twin plugs the individual fingers are two-conductor units, of which the part entering the jacks is practically the same as the corresponding part of the No. 47 plug. Examples are plugs used for connecting operators' headsets, and those used for toll test boards. Other twin plugs have three conductors in each finger, and consist of two No. 110 plugs mounted with a single shell. They are used principally for connecting the balancing network of cord circuit repeaters.

In addition to such plugs as have been described, there are in the telephone plant many contact-devices of unique design for special purposes. Some, in the form of plugs, contain a resistance unit in series with their contacts. Others, of entirely different construction, are used in dial systems for emergency transfer of traffic from one circuit to another, and many have as many as sixty-six contacts. But although classed as plugs, these are very different from the simple, compact little members through which billions of calls are completed yearly.

Humidity Test Equipment

By E. B. WOOD

Apparatus Development Department

MILDEWED garments and swelling or sticking bureau drawers are commonplace phenomena in the summer time. They are particularly so in rainy weather. In winter, on the other hand, in heated homes, a shrinkage or warping of furniture and doors is equally common. If we seek the causes of these changes in materials between summer and winter we find it due to the amount of moisture or water vapor which is in the air and therefore available for absorption by wood or other fibrous or absorbing substances. In a room having a volume of one thousand cubic feet the air in winter contains normally less than one-fifth of a pint of water in the form of vapor while in summer the amount may be one and a half pints, or more than seven times the winter quantity.

The amount of water vapor in the air is generally measured in per cent of the maximum amount the air can hold at that temperature and pressure. This percentage is usually spoken of as the relative humidity. The summer condition mentioned above corresponding to approximately ninety per cent relative humidity at 85 degrees Fahrenheit is so near to the saturation point that the addition of one-fifth of a pint of vaporized water or a drop of three degrees in temperature would result in the formation of fog.

It is not surprising in view of these data and experiences that telephone apparatus with its complex electrical circuits and closely adjusted moving parts should be especially susceptible to the effects of moisture. The importance of such effects has been recognized in the design of telephone

apparatus for many years. However, as the extension of machine-switching and long distance communication systems has demanded closer operating limits and more rigid requirements for apparatus, the importance of atmospheric conditions has greatly increased and a more precise knowledge of their effects has been required.



Interior of large cork-insulated room, showing cable wires and terminal blocks undergoing test

In response to the demand for improved facilities for the study of the effects of humidity, laboratory testing methods and equipment have been completely revised within recent years and additional testing facilities are constantly being provided as the volume of humidity testing increases. The equipment in present use in the General Development Laboratory may be divided into three groups comprising large cork insulated rooms, air-tight stationary chambers and small portable units.

In the first group we have three rooms, each of approximately 1500 cubic feet capacity. The temperature and humidity of each are controlled by a system of sprays and water-cooled radiators or electric heaters, through which the air from the room is circulated by a centrifugal blower and so is conditioned as desired. This apparatus is capable of reproducing atmospheric conditions ranging from 30% to 95% in humidity and from 70 degrees to 110 degrees F. in temperature, thus covering practically the entire range of conditions normally existing in telephone buildings. The operation of the equipment is automatic and the accuracy normally obtained is plus or minus one per cent in humidity and plus or minus one-half degree F. in temperature. These rooms are large enough to permit the testing under actual operating conditions of large pieces of assembled apparatus as well as small parts and raw materials. An important feature of this equipment is its flexibility, permitting sudden changes in humidity and temperature to be made and thereby allowing apparatus to be studied under the fluctuating conditions which have been found to exist in nature.

In the second group we have two chambers, one of fifty and the other of four cubic feet capacity. These consist of an inner air-tight chamber within a surrounding compartment

which is thoroughly heat-insulated from the outside air. The humidity in the inner chamber is controlled by the use of a solution of sulphuric acid contained in a large shallow lead tray over which the air is circulated by a fan. The manner in which the sulphuric acid and water control the humidity will be discussed later. The temperature is controlled by thermostatically regulated electric heaters located in the eight-inch surrounding compartment. For temperatures below room temperature an ice-box is provided through which the air in the outer enclosure is circulated by a blower. The walls of the inner chamber are composed of layers of wood, paper, air spaces and cork, and heating and cooling are accomplished by means of heat conduction through these walls from the outer air spaces. This arrangement lends itself to extremely accurate control of temperature and humidity within the inner enclosure, the variations under normal operating conditions being too small for measurement. This may be called precision equipment. It is best adapted for use in tests requiring constant humidity and temperature for comparatively long periods such as corrosion tests, or for tests requiring extremely accurate and constant atmospheric conditions.



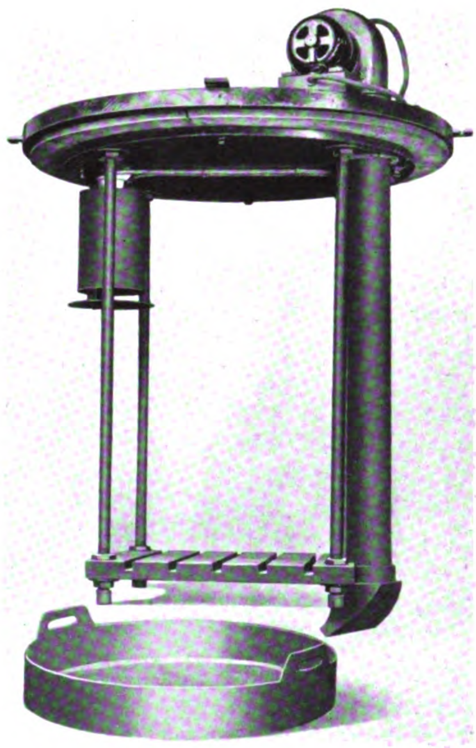
Small air-tight chamber for accurate humidity control

The type of portable equipment comprising the third group was developed in response to the demand for a low cost equipment suitable for use in commercial inspection-testing of raw materials and manufactured articles such as wire and small apparatus, and to provide additional equipment for laboratory testing. Twelve or more of these units are now available, each having a capacity of approximately eight cubic feet. This equipment consists of a large earthenware crock surounded by a wooden case, the space between the crock and case being filled with granular cork for heat insulation. A thick wood top is provided on which is mounted a small blower for circulating the air in the crock, a rack for holding samples, and a heater lamp controlled by a thermostat located in the blower intake duct. Humidity is controlled by a saturated solution of a suitable inorganic salt. The humidity within the enclosure is measured by means of wet and dry bulb ther-

mometers inserted in the blower intake duct through a cork.

The equipment is capable of producing humidity conditions ranging from thirty per cent to ninety per cent and temperatures from approximately room temperature to 100 degrees F. No provision is made for obtaining conditions below room temperature, but if such a condition is required, the whole apparatus may be placed in a cooled enclosure. Under normal operating conditions, the humidity is maintained within plus or minus two per cent and the temperature within plus or minus one degree F.

The use made of the sulphuric acid and saturated salt solutions rests on some very interesting physical facts. If pure water is placed in an air-tight chamber, the humidity will increase until saturation or 100% relative humidity is reached. According to the accepted theory molecules of water moving about in the liquid at high velocity escape from the surface and fly about in the space above it. Some molecules return but the number returning is less than the number escaping and consequently the amount of water vapor in the space increases steadily until finally the number returning is equal to the number escaping and no further increase in water vapor is possible. The space is then said to be saturated and the relative humidity is one hundred per cent. The vapor exerts a pressure inside the chamber and that exerted at one hundred per cent humidity is called the vapor pressure of the water at that particular temperature and pressure. The relative humidity at any time during this evaporation process may be defined as the ratio of the number of molecules per unit volume to the number per unit volume at saturation, or since for a given temperature the vapor pressure is proportional to the number of molecules the relative humidity may be defined as the ratio of the vapor pressure in the space above to the vapor pressure of the liquid.



Portable heating and circulating equipment, used with a crock which forms the testing chamber

If a soluble material which has practically no vapor pressure of its own is added to the water, the vapor pressure of the solution becomes less than that of pure water. Therefore, if an aqueous solution such as a sulphuric acid or soluble salt solution is placed in the chamber, the humidity at equilibrium will be less than one hundred per cent; choice of the proper concentration will give whatever predetermined humidity condition may be desired.

For humidity control systems which are practically air-tight, sulphuric acid solutions possess certain advantages over saturated salt solutions. Humidities ranging from five per cent to one hundred per cent may readily be obtained by simply varying the concentration of the solution. The effect of small changes in temperature on the resulting humidity is negligible, the change in humidity being in general less than one-tenth per cent per degree centigrade. Sulphuric acid itself has practically no vapor pressure, the most delicate tests having failed to indicate any trace of acid fumes in the atmosphere of the test chamber.

For humidity equipments which are not completely air-tight, such as the portable units described above, sulphuric acid solutions or other unsaturated solutions are not satisfactory since the concentration gradually changes by evaporation or by the addition of water absorbed from the atmosphere. This difficulty has been overcome satisfactorily, however, by the use of saturated salt solutions. As an example, a saturated solution of sodium chloride (common salt) has a definite vapor pressure at a given temperature which will give a humidity of seventy-five per cent. If an excess of the salt is present in the solution the addition or evaporation of water has no effect upon the vapor pressure since the solution is at all times saturated. Thus it is possible to maintain a practically constant humidity in a non-air-tight system provided, of course, that reasonable precautions to restrict air leakage are observed.

Data are available in the literature on the vapor pressures of saturated solutions of soluble materials which may be used to control humidity over a wide range. Also in many cases, two or more salts may be used in combination to increase the range of humidity obtainable by this method. In the laboratories, this method has been used mainly for maintaining humidities ranging from sixty-five per cent to ninety-five per cent, but it is known that humidities at least as low as thirty per cent are similarly obtainable.

In the use of this method some precautions should be observed. Temperature has in general much greater effect upon the vapor pressure than is the case with sulphuric acid solutions. In some cases the vapor pressure-temperature curve is apparently irregular. The stability characteristic of each salt should also be known in order to insure freedom from gaseous impurities in the test chamber. In short, each salt must be given careful consideration as to its characteristics before being used. Such precautions having been observed, however, saturated salt solutions have the advantages of being inexpensive, easy and safe to handle and requiring no maintenance even though the conditioning period may extend over many months.

Commercial Generator for Central Office Power Plants

By M. A. FROBERG
Systems Development Department

WITH the development of the electrolytic condenser, it has been found possible to substitute for central office charging purposes a commercial generator for the Type M generator now standard.

The Type M generator was originally designed to furnish "quiet" current to storage batteries and telephone circuits and it has fulfilled its functions in a very satisfactory manner. Recent tests made with generators of commercial design equipped with suitable filters indicated that direct current could be furnished to central offices at a smaller cost than with the type M generator. The development in the Laboratories of the electrolytic condenser, an essential element in these filters, was described by H. O. Siegmund in the RECORD for April, 1927.

While a storage battery can be charged by any direct-current generator of suitable voltage and output, telephone generators have been required to do much more than charge the central office battery. Much of their output goes into talking circuits to be modulated by telephone transmitters. It goes without saying that such currents must not contain alternating components within the audible

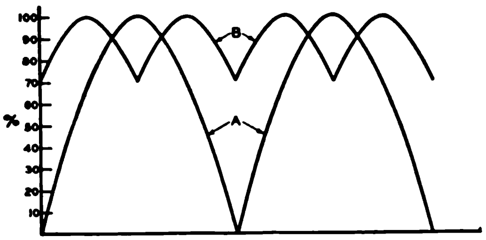


Fig. 1. Voltage waves of a simple direct-current generator: (A) of a single coil; (B) of two coils

range. Hence the Bell System has always insisted that a charging generator must have as "quiet" an output as possible.

Why a direct-current generator of the usual commercial type will have an output too noisy to use in a telephone circuit is evident from its de-

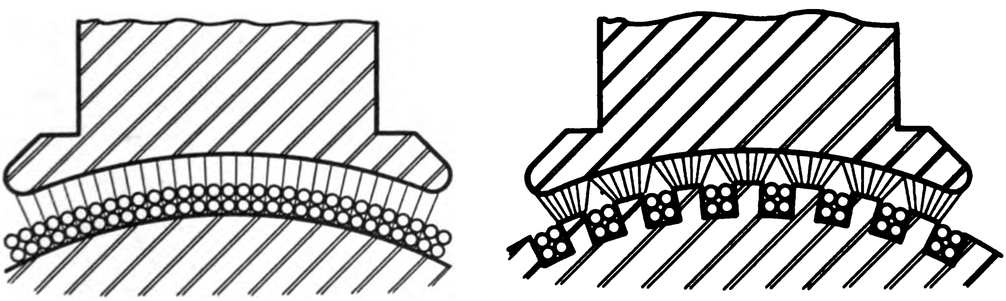


Fig. 2. Effect of armature teeth on flux distribution: left, a smooth-core machine like the type M generator; right, a slotted core like the commercial-type generator

sign. A single coil rotating in a magnetic field produces a voltage which rises from zero when the conductors are between poles to a maximum when they are under the poles and cutting the flux at its densest point. This cycle is repeated for each pole, and so a plot of the voltage for such

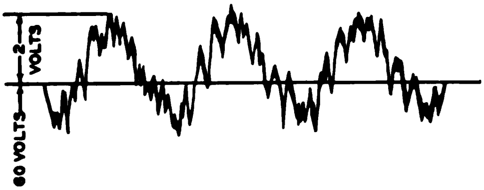


Fig. 3. Voltage wave of a typical commercial-type generator

a single-coil generator would resemble A of Figure 1. Such a generator, with its voltage swinging from zero to maximum at a frequency equal to the number of poles times the revolutions per minute, would be impossibly noisy. If two coils were used in place of one, the potential curve would resemble B of Figure 1. This is a big improvement as the magnitude of the ripple in the voltage wave is cut considerably. As the number of coils is further increased the ripples are reduced still more in size.

These basic variations in the voltage wave are not the only ones, however. The armature coils are laid in slots and the flux, concentrating naturally in the teeth due to their greater permeability, has an uneven distribution. As a result, corresponding high-frequency ripples are generated due to the flux dropping back from tooth to tooth as the armature rotates. Another source of irregularities in the voltage wave is variation in the air gap which causes differences of flux densities. A typical result of these factors and other minor ones is shown in the oscillogram pictured as Figure 3. The direct-current voltage here is about sixty but superimposed on it are the ripples, shown with a magnitude of over two volts, which make the current far too noisy for use in talking circuits of the usual types.

Because of these facts it was necessary to design a special machine with a more nearly smooth and thus quiet voltage wave. As a basis a large number of coils were used with a correspondingly large number of bars in the commutator. A smooth-core armature was utilized as shown in Fig-

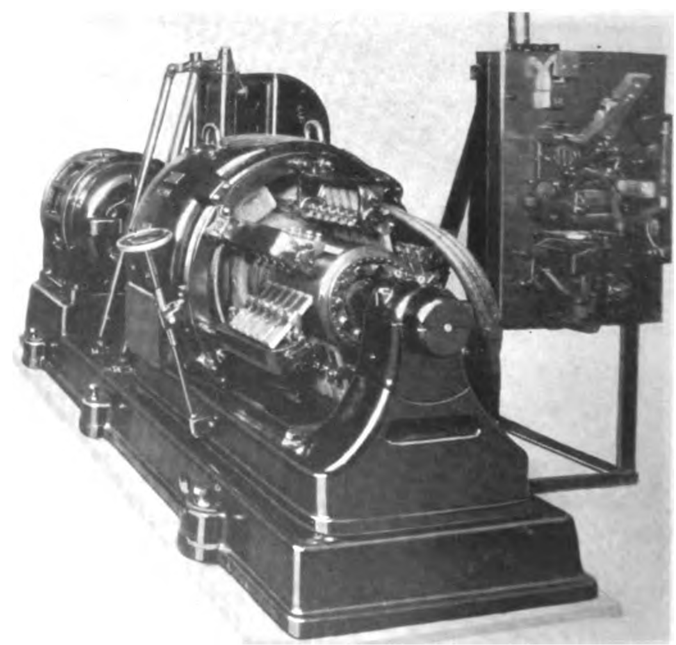


Fig. 4. A type M generator, driven by an induction motor

ure 4 and by the elimination of the teeth a more even distribution of flux was obtained. The type M generator, as it was called, differed also in other minor ways but as a result gave splendid service. Scarcely any variations in the voltage line can be detected on an oscillogram.

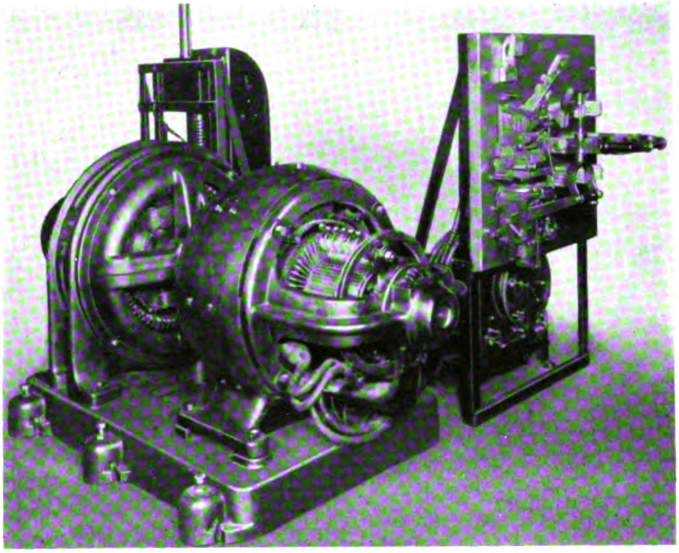


Fig. 5. A commercial-type generator, driven by a synchronous motor

It is obvious that the type M machine should cost more to manufacture than a commercial type generator because of the special design and of the small number made each year.

It is expected that in addition to the savings in first cost which will be made by employing commercial generators, there will also be a saving in maintenance; the brass gauze brushes of the Type M generator have probably required more frequent attention than will the carbon brushes of the commercial-type machine.

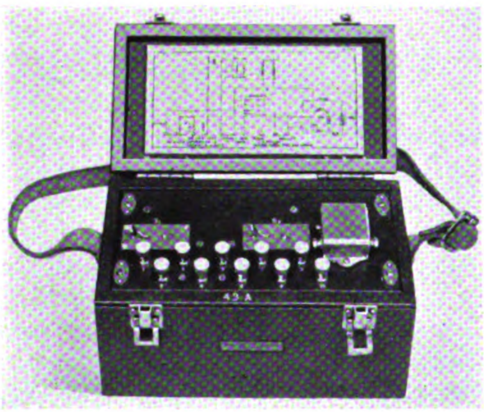
With the availability of suitable filters to suppress noise-making currents, it became possible at once to use the commercial machine and save both in original cost and in upkeep. Before the commercial generators were put into general use, however, extensive field tests were conducted by engineers of the American Telephone and Telegraph Company and the Laboratories in the panel office at Stillwell, Long Island City, in the combined step-by-step and toll office at Reading, and in a manual office at Wellesley, Massachusetts. These installations proved the value of the equipment economically and from the standpoint of circuit noise as well.

Coincident with the change of generators, the synchronous motor has been made available as the driving element. This has brought about an improvement in power-factor, not only of the unit itself, but of the entire central office installation, since the synchronous motor can be operated at a leading power factor to offset the lagging current of induction motors used for other conversion units and for other purposes. In one case it would have been necessary to install an expensive condenser for power-factor correction, had not the synchronous motor been available.

Cable Splicers' Test Set

By H. C. RUBLY
Apparatus Development Department

MORE than is at first evident is involved in the splicer's job of joining together adjacent lengths of telephone cable. In many cases each wire must be identified by the splicer and by his helper at the other end of the cable section, so that connections can be made accord-



The test set ready for use

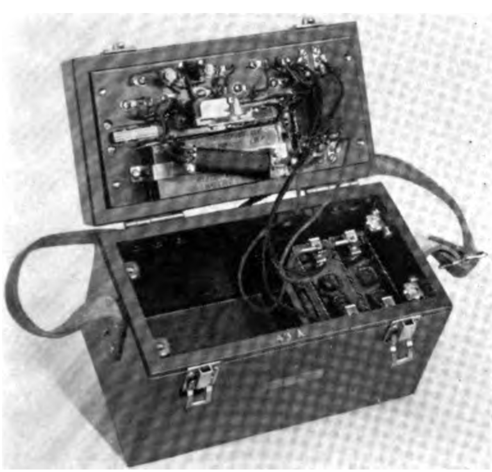
ing to plan. Defective wires must be identified and segregated. For part of the work splicer and helper must communicate with each other, and in addition it is often necessary for them to be within call of the central office.

Portable apparatus for testing has been provided almost as long as cables have been used. Talking facilities between splicer and helper and a buzzer by which they could be called when wanted, at first provided separately, were later combined with the test sets. Thus modified, the sets have been reasonably satisfactory, depending upon the ingenuity of the user, and have remained practically unchanged in circuit essentials for over twenty years. In arrangement and mounting, however, the greatest diversity has been shown. From the earliest stage when the circuit members were mounted on boards or in similar informal fashion, the assemblies passed through many stages, culminating generally in portable apparatus designed by each of the Associated Companies for its own use. It is with these sets and with Western Electric test set No. 16A, now superseded, that the necessary tests have been made during installation and maintenance of local cables.

A standard test set, No. 43-A, has been designed in collaboration with T. C. Henneberger and A. L. Richey of the Department of Development and Research of the American Telephone and Telegraph Company, and is manufactured by Western Electric. Embodying all the features needed for installation and maintenance of local cables, it gives greater compactness and convenience than the older sets which it supplants. It weighs only eight pounds, and is less than a foot long and about six inches square; it can therefore be taken into a manhole or to the top of a pole with a minimum of inconvenience. Yet it fits the splicer to meet all the routine requirements of his work, and in addition equips him to locate sev-

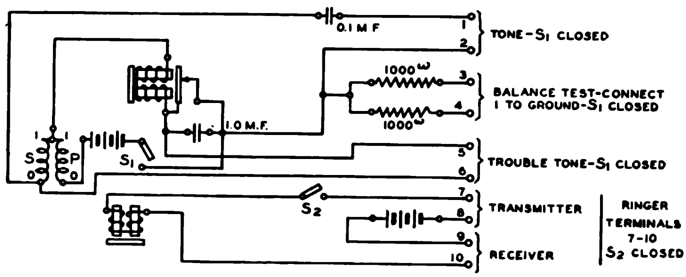
eral types of faults in cable already installed.

For identifying wires before splicing, one of the first requirements, tone is provided between terminals 1 and 2 by the interrupter and induction coil connected to the battery. One of the terminals is connected to ground by the splicer, and the other to the wire chosen. Then the helper at the other end of the cable section connects one side of his receiver to ground, and the other side successively to various wires of a hundred-pair group,* until he is notified by the tone which has come through from the test set that he has picked the wire chosen by the splicer.



Circuit members assembled on lower side of the panel

For comparing capacitances of wires or of pairs, two non-inductive resistances of a thousand ohms each are provided, connected to terminals 3 and 4. A splicer connects to one of the terminals a wire or pair of wires which he knows is good; then



Circuit diagram of the test set

he connects the wire or pair to be tested to the other terminal, and attaches his receiver to the two terminals, thereby forming a Wheatstone bridge. Alternating current from the induction coil passes to ground from terminal 1, and in case of unbalance to ground in capacitance of the wires or pairs being tested, it flows through the receiver between terminals 3 and 4, resulting in a tone there.

For conversation between splicer and helper, terminals 7 and 8, and 9 and 10 provide for connection of transmitter and receiver; the battery between terminals 8 and 9 energizes the talking circuit. A line from the central office is connected to terminals 7 and 10 when a call is expected, and the switch S2 is closed; at such times the receiver and transmitter should not be connected to terminals 7 and 10, since the shunt which they provide makes it possible that the buzzer may not be operated when a signal is received.

The battery between terminals 8 and 9 provides, in addition to talking current, a source of current for the "receiver-battery" test, by which defects of almost any sort in new cables

** Each group of not more than one hundred pairs is identified by the color of insulation of each pair.*

are detected. For broken wires, grounded wires, crossed or short-circuited pairs, the battery is connected through a receiver in succession to the



The "receiver-battery" test; contact is made with each wire in turn by the scissors

various wires. In testing for a grounded wire, the other terminal of the battery is connected to the cable sheath; when the defective wire is reached in testing a flow of current passes through the receiver, and is registered by a click. Wires broken, crossed and short-circuited are found in somewhat similar fashion.

It is at times necessary to locate faults that develop in cables during service. A test set for this special use, 20-C, is ordinarily employed, but since on account of other requirements the 43-A set contains the necessary parts, it can be used for fault locating on certain types of cables. The "trouble tone" or "exploring coil" tests that are made consist in sending alternating current through the defective wire, and getting it back through the cable sheath or another wire, depending upon whether the fault is a grounded or a crossed wire. The changing magnetic field surrounding the cable is picked up by an "exploring coil," really the secondary of an air-core transformer of which the circuit under test is the primary. The exploring coil is in a varying magnetic field as long as it is between the test set and the circuit fault, but when it passes beyond that point a current is no longer induced in its windings, if the circuit is short and non-loaded. Under such circumstances the two manholes or two poles between which the fault exists can readily be found; when desired the defect in an aerial cable can be found within a few inches by use of a ladder or a suspended seat by which the exploring coil can be taken to any point.

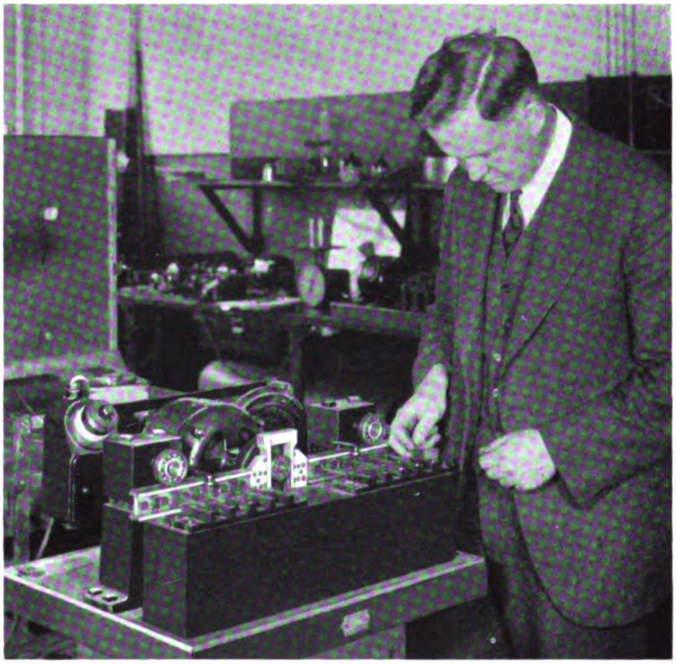
The 43-A test set is not intended for use with toll cable, where testing in installation and maintenance is much more exacting. For local cables, however, its accuracy, completeness and convenience make it an excellent tool for all-around work.

Strength-Tests of Telephone Materials

By J. R. TOWNSEND
Apparatus Development Department

RECENT developments in the mechanical arts have been of necessity away from the ponderous, slow-moving machines of an earlier day toward the concentration of large power in small bulk, with accompanying high unit stresses. Compare the giant alternators of twenty years ago, with their huge triple-expansion engines, to modern turbine-generators; visualize the original gasoline engine alongside an airplane motor — one hundred times the power for the same weight. To gain these advantages, newer and stronger materials were developed: we see cast iron replaced, in turn, by wrought iron, steel, and finally alloy steel—each step an enormous advance in strength and durability.

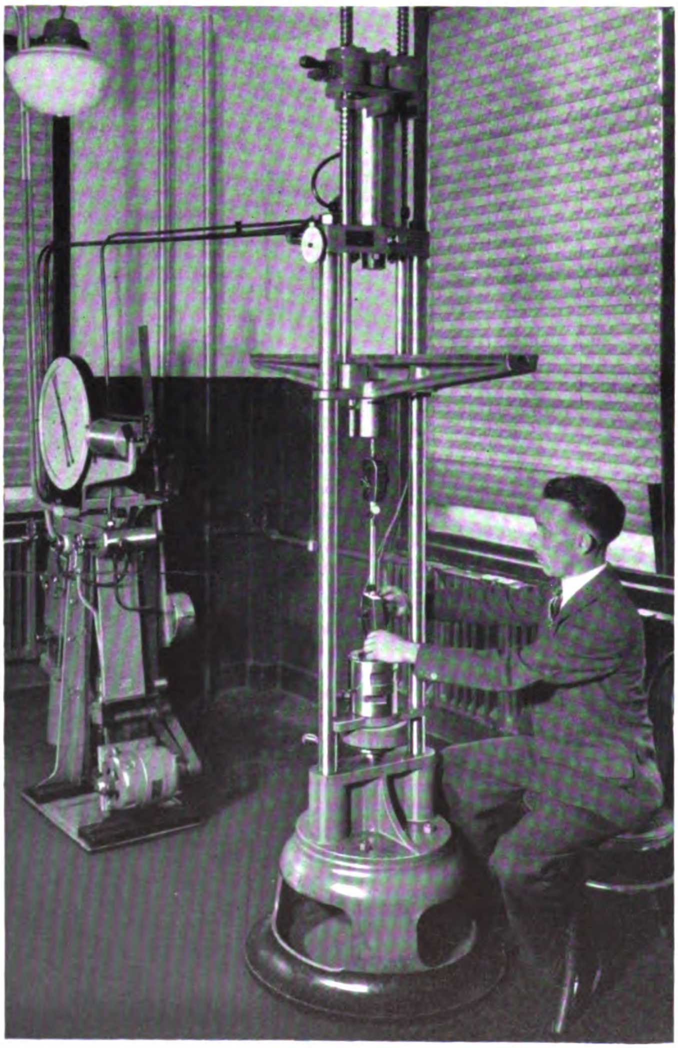
Under the stress of the World War, still further economies had to be effected, and engineers throughout the world reluctantly reduced factors of safety. Then surprising things happened. Machine parts broke in service although they were not stressed to more than half their ultimate strength. Several series of investigations were started: one by the National Research Council, to which the Western Electric Company, among others, contributed. This work was carried on at the University of Illinois; other investigations were made at the United States Naval Experiment Station and by Army engineers at McCook Field.



A machine built in the Laboratories for fatigue tests of sheet spring material, and W. S. Hayford, its designer

As a result of these tests our ideas of strength-of-materials have been completely revolutionized. It is now realized that the classical theory treated metals as homogeneous and

as having the same properties in every direction. These assumptions are now known to be untrue; for example, modern metallurgical studies show that metals that have undergone certain treatment may be composed of long, narrow crystals which impart to the specimen a rather fibrous structure. Further, no account had been taken of the effect of *repeated* stresses, in spite of the publication in 1860 by Woehler of a long series of tests. Woehler showed that when stressed again and again, iron and steel will withstand much less than their ultimate (static) strength; that the specimens will hold their strength practically up to final failure, and that they will break with no warning whatever.



The laboratory's most versatile machine: it will determine resistance up to 20,000 pounds to tension, compression and bending stresses. L. J. Burns is pictured as he prepares for a test of tensile strength

As a result of the tests of the last few years, it has been demonstrated that for steel the safe limit for repeated stress is but forty to fifty per cent of the ultimate strength, and for annealed brass it is only thirty per cent. Tests at the Forest Products Laboratory have found definite limits for the wood used in airplanes, at about thirty per cent. A number of investigations have shown that concrete, too, has its limitations: fifty to fifty-five per cent of its ultimate compression strength.

Certain telephonic materials are subjected to repeated stress: cable sheath, for example, and contact springs. In the General Apparatus Development Laboratory we are actively engaged in fatigue studies of cable-sheath alloys, and of spring materials. We have

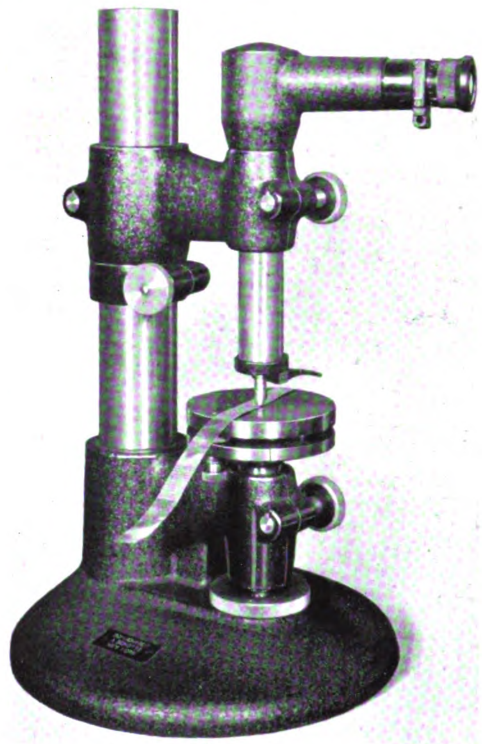


A Rockwell hardness-tester in use by E. F. Berry

learned a great deal about the effects of alloying substances, of heat treatment, of working, of manufacturing defects, and of abuse during adjustment of spring parts.

Results of all these investigations have completely revolutionized our ideas of mechanical testing of material. Until recent years, much testing concerned itself mainly with dogmatic procedures where the breaking, twisting and bending strength were determined. Results of static tests on small samples were applied to the design of structures of great size, often subject to dynamic stresses. In the light of our present knowledge, it seems remarkable that these earlier structures were so successful and that disaster was so rare. The answer lies in the generous factors of safety allowed. Nowadays we believe that the elastic limit cannot be taken as a safe basis for design. Rather, the endurance limit should be used, with the static tensile test as a quick inspection test only.

Another property of materials which has received much attention is that of hardness. This may be defined as the resistance of a material to deformation—in particular, to the deformation caused by pressing a small penetrator into the body of the material. This property is tested directly by the Brinell and Rockwell methods and indirectly by the scleroscope. All of these methods are used in our laboratory. The Brinell test



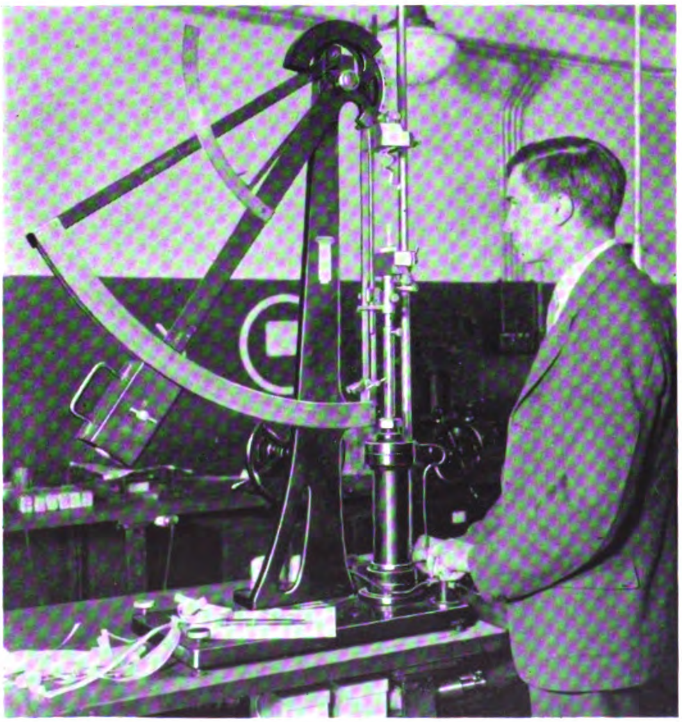
Differences in thickness of one hundred-thousandth of an inch are detected by this instrument

is to force a steel ball into the specimen and measure the diameter of the resulting indentation. This value, and the pressure applied, give a

numerical measure of the hardness. The Rockwell test is similar, but on account of its smaller penetrating-point and lighter loads it is better adapted to thin sheet metal and to soft metals such as aluminum and lead. The scleroscope measures the rebound of a weight when dropped from a fixed height on the test specimen. This test is not well suited to sheet metals because it is too sensitive to casual variations in the testing instrument itself.

All of these hardness tests are comparative rather than absolute; in some cases their results have been found to correspond closely with the performance of materials in actual service; in other cases they are entirely valueless. Considerable work is being done to associate hardness with other physical properties. Hardness is often considered as an indication of ultimate tensile strength. On the other hand, work done in these Laboratories on lead alloys has shown that annealing will effect enormous changes in hardness and practically none in tensile strength.

Since Hawthorne makes extensive use of drawing operations on sheet metal, it is important to know the suitability of materials for this work. The Erichsen test is to force the sheet into the form of a cup whose depth before the material cracks is a measure of ductility. This is a "static" test; its results do not reveal the performance of a material on a punch or forming press at production speeds. A "dynamic" test has therefore been worked out in which the cupping is carried forward at ninety strokes a minute, to simulate factory conditions.

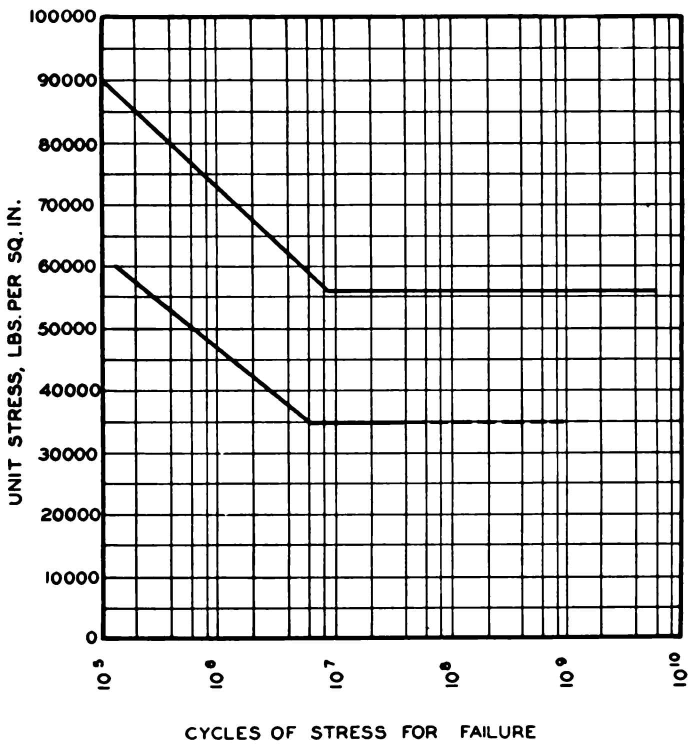


Tensile testing of thin metals: a sample of duralumin diaphragm-stock has just been broken by I. V. Williams

Impact tests are also made in this laboratory by allowing a pendulum to swing against and break a sample of the material. The pendulum will fail to rise to its free-swinging height by an amount which measures the work done in breaking the sample. This value is useful in comparing molded and cast materials, particularly die castings, as to brittleness.

To keep pace with the exacting requirements as to strength, lightness and cost which are being placed upon materials, there is hardly any form of

testing which is not undergoing revision today. In one direction, tests are being simplified and standardized so that they can be used in the inspection of raw materials; in another direction new tests are being designed to reproduce under controlled conditions the stresses which materials will meet in actual service. Both paths converge at the goal of better and more dependable materials for the telephone plant with a saving to telephone users.



Graph of Woehler effect - reduction in breaking stresses as tests are repeated

News of the Month

To John J. Carty, Vice-President of the American Telephone and Telegraph Company and Chairman of the Board of Bell Telephone Laboratories, has been awarded the John Fritz Medal "for pioneer achievement in telephone engineering and in the development of scientific research in the telephone art". This gold medal is awarded not oftener than once a year for notable contributions to scientific or industrial progress. Among the distinguished engineers who have previously been awarded the medal are Lord Kelvin, George Westinghouse, Alexander Graham Bell, Thomas Alva Edison, General George W. Goethals and Orville Wright.

Mr. Jewett attended the Presidents' Conference held at Yama Farms, October 11 to 17.

Mr. Craft entertained at luncheon Admiral Bullard and two other members of the Federal Radio Commission, Messrs. Pickard and Caldwell, on October 28. The guests made an inspection visit of the Laboratories preceding the luncheon.

* * *

Members of Edward J. Hall Chapter of the Telephone Pioneers of America, and relatives, about four hundred and fifty in number, attended a television demonstration in the auditorium the evening of November 2. John Mills introduced H. E. Ives, and spoke briefly of the development work leading up to the public demonstration. Then Dr. Ives described the requirements and methods of television, illustrating his talk with lantern slides. The meeting ended with a demonstration of the apparatus.

R. V. L. Hartley spoke at the Colloquium on October 24, on "Frequency Relations in Electrical Communication". At the next meeting, November 7, K. K. Darrow spoke on "Resonance Radiation".

Research Department

Harvey Fletcher was the principal speaker at a luncheon of the New York League for the Hard of Hearing, held October 21 at the Hotel Commodore. Telling of the astonishing number of school children shown by investigation to be partly deaf and the degree to which their progress in school is retarded, he called attention to the need for thorough measurement of hearing of all the pupils and medical care for those shown to need it.

A. C. Keller, E. Dickten, C. B. Northrop and I. S. Rafuse conducted special tests on high-speed circuit breakers at Bryn Mawr, Pennsylvania, for a period of about two weeks. The tests were made jointly for the American Telephone and Telegraph Company and the Pennsylvania Railroad.

H. A. Frederick, F. Gray, C. R. Moore, H. H. Lowry, A. W. Hayes and J. T. L. Brown were at Hawthorne, arranging certain features of handset manufacture.

A. G. Russell visited the laboratory of the Chromium Corporation at Waterbury, Connecticut, on No-

vember 3 to inspect equipment and methods for chromium plating.

O. J. FINCH, W. G. Knox and H. Boving made a general inspection of the experimental and testing laboratories for Duco lacquers at the Du Pont works at Parlin, New Jersey, on November 4.

R. R. WILLIAMS and H. H. Lowry visited the electrical engineering laboratories of Johns Hopkins University, Baltimore, on October 25, and were especially interested in the work on insulating materials.

H. E. IVES delivered a lecture on television to a meeting of the Western Society of Engineers, held in Chicago, October 17. At a meeting of the Optical Society of America held at Schenectady on October 20 he presented a paper written by himself and A. L. Johnsrud, jointly, entitled "The Thickness of Spontaneously Deposited Photo-electrically Active Rubidium Films, Measured Optically."

THE JOHN SCOTT MEDAL recently awarded to H. E. Ives was formally presented to him at a meeting of the Franklin Institute held at the Institute's rooms in Philadelphia on November 16.

APPARATUS DEVELOPMENT DEPARTMENT

E. B. WHEELER spent the week of October 24 at Hawthorne in connection with development of enameled wire and of switchboard lamps. On the return trip he inspected the manufacture of Blue Bell dry cells at the factory of the National Carbon Company at Fremont, Ohio, and visited the new toll office at Cleveland.

E. L. NELSON spoke at the monthly luncheon of the Western Electric Company on December 2, on "Our New High Power Broadcasting Equipment".

F. R. MCMURRY has been at the factory of the Morkrum-Kleinschmidt Company in Chicago for several weeks, inspecting and testing models of the 15-type telegraph printer.

THE WHIPPANY LABORATORY was visited on November 14 by representatives of the metropolitan newspapers and radio magazines. Equipment, particularly the new fifty-kilowatt broadcasting transmitter, was explained and demonstrated by E. L. Nelson, A. W. Kishpaugh, F. M. Ryan and their associates.

G. A. ANDEREGG spoke on "Submarine Cable Engineering" at the meeting of the American Electrochemical Society held November 18.

W. V. WOLFE was at Chicago as a member of the Sub-Committee on Interference of the National Electric Light Association. The purposes of the committee are to inform power company officials on the problems involved in power line carrier telephone work and to formulate plans for avoiding interference between adjacent carrier systems.

R. D. GIBSON, J. D. Sarros, K. O. Thorp and C. N. Nebel are on the Pacific coast, installing a power line carrier telephone system of new type on transmission lines of the Pacific Gas and Electric Company. This system will provide communication between Claremont, a district in Oakland, and Pitt River, two hundred miles away.

SYSTEMS DEVELOPMENT DEPARTMENT

C. BORGMANN, H. G. W. Brown, F. S. Kinkead and P. L. Wright visited the new toll office at Cleve-

land and the new panel-type dial office there.

W. J. LACERTE inspected new centralized testing equipment in step-by-step offices at Reading, Pennsylvania.

F. B. ANDERSON visited Philadelphia and Reading in connection with a study of high resistance faults in toll cables. For the same study R. A. Jascoviak went to the repeater stations at Harrisburg, Pittsburg, Bedford and Ligonier, and at Shippensburg, Maryland.

E. K. EBERHART visited the step-by-step offices at Reading and Allentown, Pennsylvania, for studies of lighting equipment used in central offices.

F. F. SIEBERT and C. W. Van Duyne visited the Westinghouse Electric and Manufacturing Company at East Pittsburgh.

S. B. WILLIAMS addressed the student branch of the American Institute of Electrical Engineers at the City College of New York on November 17. He spoke on telephone switching, and showed the film, "Through the Switchboard".

C. H. ACHENBACH went to Hawthorne in connection with improvements in panel-type dial offices.

OUTSIDE PLANT DEVELOPMENT DEPARTMENT

R. L. JONES and C. S. Gordon, with engineers of the American Telephone and Telegraph Company and of the New Jersey Bell Telephone Company, conducted tests on a wire splicing device at Linden, New Jersey, on November 3.

E. M. HONAN and R. C. Dehmel were at the plant of the Habirshaw Cable and Wire Corporation in Bridgeport, Connecticut, on November 11, discussing problems involved in the manufacture of parallel drop wire.

J. M. HARDESTY and E. St. John conducted trials of transposition brackets at Mount Kisco, New York, on October 28.

L. W. KELSAY visited South Norwalk, Connecticut, and various places in Westchester County, New York, during the latter part of October, making investigations in connection with cable terminal installations.

INSPECTION ENGINEERING DEPARTMENT

W. A. SHEWHART visited the Forests Products Laboratory at Madison, Wisconsin, on October 27 and 28.

P. S. OLMSTEAD was in Hawthorne during the first week of November in connection with inspection and manufacture of handsets.

E. G. D. PATERSON was in Pittsburgh from October 19 to 22, discussing quality control problems with Hubbard and Company, suppliers of outside plant hardware.

ON OCTOBER 18, W. C. Miller and O. A. Shann visited the Gray Telephone Pay Station Company in Hartford, Connecticut, to discuss manufacturing and inspection problems connected with the 50-G coin collector.

E. F. HELBING and E. C. Manderfeld visited Electrical Research Products, Incorporated, in Philadelphia on November 3, to inspect the stock of regulated motors used in tone reproducing systems.

ON NOVEMBER 7, L. E. Gaige was in Philadelphia to investigate questions of design, manufacture and packing of the woodwork of No. 550-C private branch exchange switchboards.

C. E. HOOKER and G. C. Porter

were in New Haven on October 21 and 22 to investigate trouble with the No. 2 Public Address System used in the New Haven Arena.

On November 7, A. Grendon visited Charles W. House & Sons in Unionville, Connecticut, to discuss the quality of felt used in bases for desk stands.

H. W. Newlund has been transferred to the St. Louis field territory to assist R. C. Kamphausen, Field Engineer in that territory.

Patent Department

H. A. Burgess, T. P. Neville and P. C. Smith visited Washington during the past month for the prosecution of patent applications.

General Staff Department

J. E. Moravec attended the recent conference of General Auditors of the Bell System at Absecon, New Jersey.

Helen M. Craig has been appointed Chairman of the Hospitality Committee of the New York Special Libraries Association for the coming year. Members of the Association are librarians in business, technical and museum libraries, and in special departments of public libraries.

M. L. Wilson spoke to about fifty students of the Science group of the West Side High School at Newark on November 4, and showed the film "The Magic of Communication."

Bell Laboratories Club

Basketball

Though the basketball team representing the Club in outside competition has for a number of years been capable of meeting the best semi-professional teams in the Metropolitan district, this year's team is even better. It has lost only one game so far, and has an excellent chance of winning the league championship. Those who have missed the past games still have a chance to see the team in action, at Stuyvesant High School. Wednesday evening, December 7, it will meet a team representing General Headquarters of the Western Electric Company; a week later it will play the Western Electric team from Hudson Street, the ancient enemies of the Laboratories on the basketball court.

Our group this year includes many veterans from previous seasons, notably O'Neil, Maurer, Gittenberger, Steinmetz, Trottere and Hanson. The new men are Christ, Hasior, Haglund and Hiscock. J. A. Waldron is coach and manager; from his knowledge of basketball comes a good part of the team's success.

The departmental league games began Thursday evening, November 10, at Labor Temple. Games are on Tuesday and Thursday evenings at 5:30; each team is to play fourteen times during the season. The league is managed by T. J. O'Neil of the main Laboratories team.

Winter Dance

The winter dance of Bell Laboratories Club will be held in the Grand Ballroom of Hotel Pennsylvania on Thursday evening, February 2. A prominent New York orchestra is to be engaged, and other corresponding

preparations made to insure an enjoyable evening for the guests. Tickets are one dollar and ten cents each, and box seats are one dollar and sixty-five cents each. Since the demand for box seats at these parties has always exceeded the number available, the Committee suggests that those planning box parties order accommodations at once from the club secretary.

Golf

The Golf Committee has arranged an indoor tournament for Monday evening, December 12, at the Vander-Built-In course, which is located at 41 East 42nd Street. Since our last indoor tournament eighteen additional holes have been installed; these will make our coming competition faster and smoother.

For the qualifying round, thirty-six holes of medal play, the entrants will be divided into two groups of approximately fifty each. The first fifty men to report to the starter will complete the qualifying round; it is suggested that while these are playing the others have dinner, and then prepare for their start about 6:30. From each group thirty-two players will be chosen, and these will be divided into eight flights for the elimination match play. A prize will be awarded in each group of the qualifying round to the player with low medal score, and to the winner in each of the eight flights of the finals. The entry fee is one dollar and fifty cents, to be paid before the night of the tournament.

Men's Bridge Club

The tournament of the men's bridge club, which started October 10, has brought to light many new stars. This year the leaders are F. V. Borland, E. M. Noll and C. A. Smith. Mr. Smith turned in a plus score of 2170 on October 17—a score for one evening's play which we think all bridge players will recognize as excellent.

Bowling

From present indications 1929 will see the Laboratories bowling league using all forty-two alleys at Dwyers. At the start of this season twenty-eight alleys were engaged, but now even these are insufficient for those who wish to bowl. For the past six seasons the league has been made up of three groups, each with eight teams. The additional group of four teams started this year has been so successful that it will be expanded to a full group of eight at the start of next season.

Many of the scores made this season have been exceptionally good. H. C. Dieffenbach, Group A, broke all league records on Friday evening, November 4, when he averaged 225 for three games. His scores were 249, 234 and 192. A. A. Carrier holds high score for a single game in Group B, 243.

Women's Basketball

The women's basketball squad is continuing vigorous practice under the guidance of C. Gittenberger, with about twenty members. Marie Boman has been busily engaged in arranging the work and in lining up games for the coming season. These will start on the fifth of January, when a game will be played with the Manhattan division of the New York Telephone Company. Later there will be a game with the International Telephone and Telegraph Company, and two each with the Seaboard National Bank and the Vacuum Oil Company; others are being arranged now.

Election of Club Officers

CANDIDATES for Bell Laboratories Club offices for the year 1928 have been selected by the nominating committee which consists of E. J. Johnson, D. D. Hagerty, J. G. Motley, G. H. Heydt, T. J. O'Neil, P. J. Higgins, A. L. Johnsrud, S. J. Stranahan and A. A. Reading.

Ballots will be mailed to all club members on Friday, December 16, and must be placed in the ballot boxes on Monday, December 19, between the hours of half-past 8 and 6 o'clock. No employee who is not a member of the club will receive a ballot. Membership application forms may be obtained from departmental representatives or from the club secretary. Applications received after December 14 will not entitle new members to vote in the current elections. The candidates are as follows:

For President

Maurice B. Long
Donald A. Quarles

For First Vice-President

William C. Calmar
George F. Fowler

For Second Vice-President

Elizabeth Van Duyne
Marie Boman

Departmental Representatives
Two Year Term

Apparatus Development

S. James Stranahan
Earl L. Fisher

Patent-Inspection Department

Robert J. Nossaman
Thomas C. Rice

Plant Department

George J. Seltzer
George Rupp

LONG FOR PRESIDENT



MAURICE B. LONG

For President

Entered the Laboratories, Research Department, 1919, after two years in the Bureau of Standards; he has been concerned, among other things, with picture transmission. Became Educational Director in 1925; has general charge of educational activities, and supervises selection of younger members of Laboratories. Represented the Research Department in 1924 on Board of Governors of the Club

LONG FOR PRESIDENT

QUARLES

QUARLES  QUARLES

Donald A. Quarles

For President

Served overseas during the War, before entering the Laboratories in 1919. Engaged in transmission engineering until 1924, when he was transferred to the Inspection Engineering Department. Now has charge of Apparatus Inspection. He is a member of the Bell Laboratories Club chess team, and has taken part in the golf tournaments.

QUARLES

William C.
CALMAR

"The Choice with a Smile"



A member of our Plant organization since 1897; now head of the Building Shop. His long experience has brought a thorough knowledge of the organization. A pleasant personality has earned a wide acquaintance throughout the Laboratories.

FOR FIRST VICE-PRESIDENT



For Second Vice-President

Elizabeth Van Duyne

Never known to miss a trick. Takes part in all the Club's social affairs. Has had a lot of experience in athletics, dramatics and general sociability. She has ideas, and knows how to put them into practice. Her present occupation keeps her in the Apparatus Development Department.



George F.
FOWLER

For First Vice-President

Since 1913 a member of the Laboratories. Has charge of Department and Visitors' service, Bureau of Publication. Active in the old Engineering Club. Has helped make a success of many social and educational functions for the Laboratories.

Marie Boman

The best part of the Bureau of Publication, and one of the most active and popular members of the Club. Manager of the women's basketball league; member of the basketball teams that have represented us in outside games; always at our dances; track star; never does a job half way.



For Second Vice-President

FOR DEPARTMENTAL REPRESENTATIVE



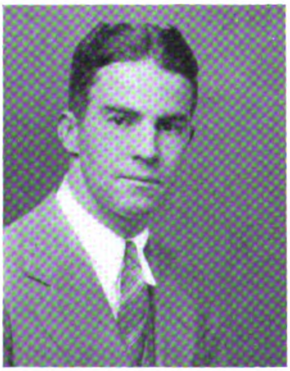
S. J.
STRANAHAN

Apparatus Development Department



E. L.
FISHER

Apparatus Development Department



R. J.
NOSSAMAN

Patent and Inspection Departments



T. C.
RICE

Patent and Inspection Departments

FOR DEPARTMENTAL REPRESENTATIVE

To Represent
the Plant Department



C. J.
SELTZER

To Represent
the Plant Department



George
RUPP

Patronize Our Advertisers

THE RECORD guarantees all candidates displayed in its columns to be 90-proof and of pre-war quality. Just off the ship. Here at last is an election in which a voter can scarcely make a mistake. From all directions are heard enthusiastic expressions of approval of the nominating committee's intelligence. And the committee's achievement is even better appreciated with the realization that it was only in response to an insistent public clamor that these ladies and gentlemen have permitted their names to be enrolled upon the ballot. They did not choose to run for office, but they have heeded the clarion call of duty, at a considerable personal sacrifice.

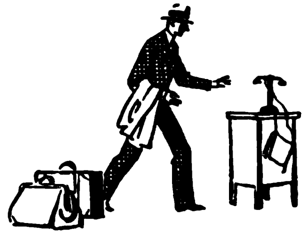
THE RECORD is pleased to announce that this year's presidential campaign will involve no noisy demonstrations. All electioneering will be carried on with a quiet dignity entirely becoming to the character of the candidates.

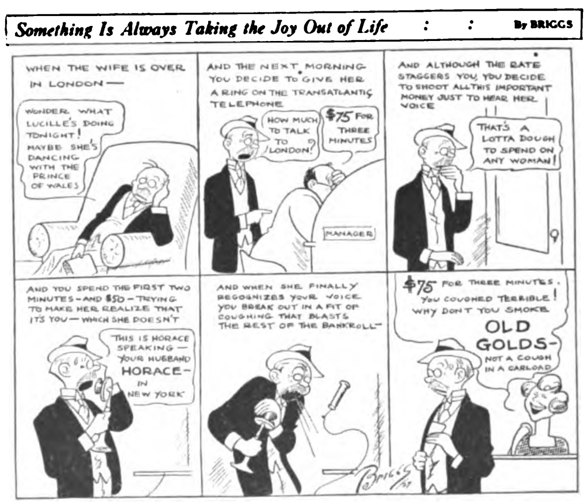
Transatlantic Telephony: A Factor in Metropolitan Life

TO those of us at the Laboratories who have been associated with the development of transatlantic telephony—and who has not in one way or another—it is interesting to note the extent to which this service has entered the public's field-of-consciousness. This is frequently typified in jests and cartoons. That reproduced below is of interest for its humor but more particularly for its implication. Evidently this manufacturer of cigarettes has felt that, while he may be giving free advertising to another business, he has also projected his story against part of the common background of our every-day metropolitan life.



The transatlantic telephone service is now being advertised by the Long Lines Department through a series in the newspapers published on the larger ships plying between the United States and England. Two sets are used, stressing the interests, respectively, of those outward bound and of those homeward bound. A talk with one's family, communication with business associates, transatlantic sales calls, conversation after the return with one's hosts and foreign friends are among the uses suggested. Convenience and speed of the service are emphasized by the slogan "Days over—minutes back" used throughout.





BELL LABORATORIES RECORD

NEW YEARS' GREETING
From President Jewett

TWENTY YEARS AT WEST STREET
By A. F. Dixon

SERVICE HONORS DURING 1927

JANUARY 1928 VOL. 5 NO. 5

Bell Laboratories Record

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BELL TELEPHONE LABORATORIES, INCORPORATED

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To My Associates in Bell Telephone Laboratories

ALL of us can take pleasurable satisfaction, I think, in looking backward over the achievements of the Laboratories organization in the year just past. It is a twelvemonth filled with notable accomplishments centered about and flowing from the work of the men and women at West Street.

Commercial transatlantic telephony, the new hand-set telephone, permalloy loading coils, the decoder sender, television, and radical improvements in talking motion pictures, are but a few of the milestones which mark progress from the experimental to the commercial through the year.

But what of the future toward which we now turn our thoughts? With so much of accomplishment to the credit of 1927, is 1928 likely to prove less interesting, less fruitful of worth-while things done, less satisfying to us than its predecessor? Emphatically, no!

In the long-cultivated fields of telephony and telegraphy the possibilities of crop improvement through research and development are apparently limitless and even more entrancing than in the past. Transoceanic telephony is but an infant, lusty to be sure, but still an infant. By-product application of our work is essentially a virgin area replete with alluring vistas.

Added to all this is a vision of the part we can and shall play in that great new human adventure, air transport. One cannot conceive of vast aeronautical development without a vast telephone and telegraph nerve system.

From every angle it is an entrancing picture which 1928 holds out to us of Bell Telephone Laboratories. Shall we profit and pleasure by what the year has in store for us? Knowing you, I know the answer — we shall.

Frank B. Jewett

Twenty Years at West Street

By AMOS F. DIXON
Systems Development Engineer

THE close of 1927 marked the twentieth anniversary of the establishment of the Bell System development laboratories at the present West Street location. This laboratory is the outgrowth of Bell's original laboratory in Boston where he, with Doctor Watson, produced the first telephone.

Prior to the issuing of Bell's patent in 1877, the Bell Patent Association was organized by a few men whom Bell had interested in his inventions. This association soon assumed corporate form and after several changes in organization to take care of the rapidly changing situation, the American Bell Telephone Company was born, early in 1880. This Company at once carried more generally into effect the policy already formulated of licensing Associated Operating Companies. The contracts with these Companies gave the licensees the exclusive right to operate within specified territory, and to use apparatus and equipment made under the Bell or any other patents owned by the American Company.

In those early days the officials of the Bell System had clearly in mind the vision of nation-wide telephone service, and felt it necessary to closely supervise the development and manufacture of transmitters, receivers, and induction coils because this transmission apparatus, which was leased but not sold to the Associated Companies, was the heart of the System and must be uniform and of the best quality in order to give high grade, uniform service. The development work on these instruments was done in a laboratory in Boston which kept pace with the needs of the System. Other apparatus, however, was bought from several companies manufacturing it under their own or Bell Company patents and supervision. The development work on this apparatus was carried on at widely separated points, and could not be as closely supervised as the work at Boston; consequently each manufacturing company incorporated in its apparatus many of the ideas of its own engineers.

The advantages to be gained from centralized manufacture of telephone apparatus for all of the licensed Operating Companies were becoming apparent and in 1882, the American Bell Telephone Company bought the plant and manufacturing business of Charles Williams of Boston where the original telephone had been made and where much of the apparatus then in use had been produced. It also bought an interest in the Western Electric Manufacturing Company at Chicago in order to merge the two in a consolidated company large enough to handle the demands of the business and operating under such centralized supervision that the highest standards could be maintained. This marked the beginning of the present Western Electric Company.

The American Bell Telephone Company had accepted the obligation to test new inventions, to improve apparatus and to furnish consulting engineering services to its licensees. To do this, it maintained the engineering department and development laboratory at Boston. The Associated Companies also had engineering departments whose function was to make possible better handling of operating problems. As the engineers of each company became more thoroughly acquainted with the technical problems of the telephone business, they naturally gave some attention to the development and improvement of apparatus so necessary at that stage of the art. The engineering department at Boston supervised this scattered development work of the Associated Companies by sending Dr. Watson and other engineers to visit them at regular intervals for the purpose of coordinating requirements and designs. The work grew rapidly, however, and it became increasingly difficult to assure adequate coordination in this way. During this period, the Western Electric Company became dominant in the field of telephone manufacture and to assist in the solution of technical problems arising in the art, it established special departments to carry on development and engineering at both its Chi-



AN EARLY TELEPHONE LABORATORY

maintained by the American Bell Telephone Company in Boston. The illustration is taken from one in "Scientific American" for September 20, 1884; *of the laboratory, we read, "the company employs a corps of expert mechanics and others skilled in the principles and practice of electricity and its allied sciences, and has provided an experimental shop, a chemical laboratory, and an electrical testing-room, fully equipped with the necessary machinery and apparatus. The experimental shop, . . . is remarkably well supplied with such tools as are required for producing and altering electrical apparatus"*

cago and its New York factories.

By 1907 the Associated Companies had been well consolidated as operating units in the Bell System, and it was apparent that if all the requirements for a certain type of service could be gathered from all the companies, standardized equipment satisfactory to each could readily be developed.

When John J. Carty in 1907 became Chief Engineer of the American Telephone and Telegraph Company (the successor of the American Bell Company), he recommended that in the interests of economy and efficiency the telephone laboratory in Boston be merged with the laboratory of the Western Electric Company at New York, and that its Chicago laboratory be also brought to New York for consolidation. He recommended further that the Associated Companies be requested to submit their suggestions and requirements for new apparatus and equipment to the engineering department of the American Company which would study them and then make definite recommendations to the newly created development and engineering department maintained by the Wester Electric Company in New York. General Carty's recommendations were adopted and in October, 1907, the central laboratories for the Bell System became a reality.

To a staff of 119 persons with Mr. Craft at its head was assigned 23,000 square feet of floor space on the eighth, ninth and thirteenth floors of Section A of our West Street building. This made a large laboratory compared with that shown in the accompanying illustration which depicts the Boston laboratory as it existed in 1884 after seven years of growth. The development organization, thus consolidated, found so fertile a field in which to work that it grew even more rapidly than before. Great advantages and economies arose from this centralization of development work. In an organization equipped with the most modern laboratory facilities and staffed by trained scientists and engineers gathered from every part of the system and from other available sources, these advantages soon began to manifest themselves in a material way to the Associated Companies.

By 1917 the laboratory was occupying 237,000 square feet of floor space, with an organization of 2,120 people. In 1925 it became a company unit in the Bell System with the name "Bell Telephone Laboratories, Incorporated." Today, with a staff of 3885 people, it occupies the entire West Street property, comprising 488,000 square feet of floor space; a part of the Hudson Street building, comprising 30,000 square feet of floor space; and over 4,000 square feet of floor space in other buildings.

As the Laboratories starts on its twenty-first year of consolidated operation, it has leased for one hundred years the northeast corner of West and Bank Streets, comprising all the remaining property in its city block. This adds approximately 28,000 square feet of ground area, which will provide space for the future growth that is certain to come.

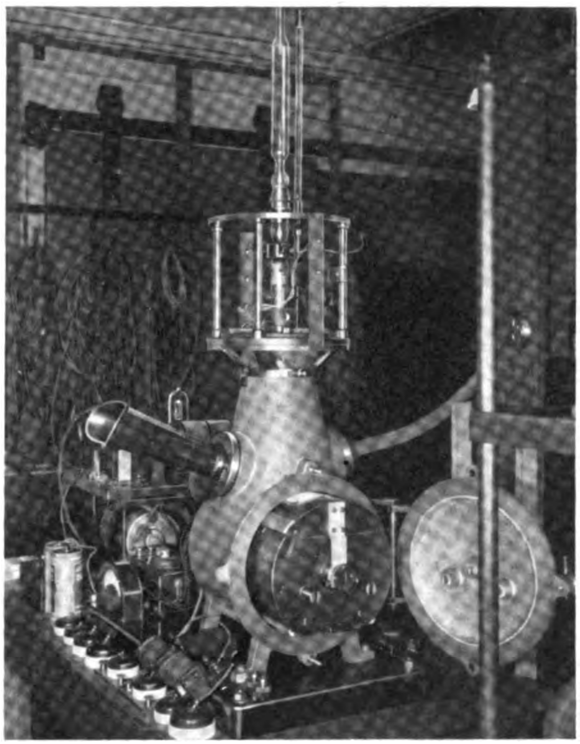
The Dufour Cathode-Ray Oscillograph

By I. E. COLE

Apparatus Development Department

EARLY last year the Laboratories were requested by the American Telephone and Telegraph Company to make an investigation of protective devices and to study their performance when subjected to transient electric waves such as might occur on telephone lines during electrical storms. From an analysis of the problem it appeared that there would be required a device capable of recording without appreciable distortion electrical waves of frequency one million cycles or higher. This was obviously out of the range of electromagnetic oscillographs whose limit is about ten thousand cycles a second. The Western Electric cathode ray oscillograph could not be considered because it makes no record of a single, non-recurring wave. It appeared that the only instrument suitable for the work was the Dufour cathode ray oscillograph, of which one or two had just been brought to this country. Accordingly a Dufour oscillograph was imported and we set to work to learn how to apply it to our problem.

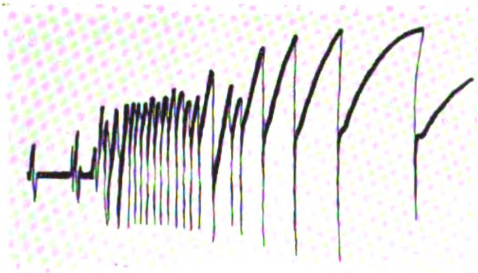
This oscillograph is one of the comparatively recent progeny of the classical Braun tube. It was developed in 1914 by a French scientist, Alexandre Dufour. His researches were interrupted by the World War and by lack of funds so that it was not until 1922 that he was able to produce a machine free enough from troubles to be of general use. Differing from the Western Electric oscillograph, its outstanding feature



A close-up of the Dufour oscillograph with the film container partly withdrawn. Above can be seen the cathode tube, and inside the housing, the deflection-tube

is the placing of a photographic film inside the vacuum chamber so that the cathode stream may impinge directly on the sensitive surface and record its trace photographically with a single traversal.

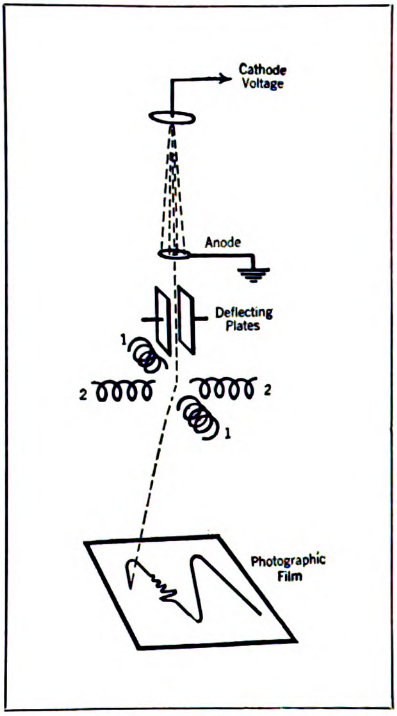
The oscillograph proper begins with a glass tube holding an aluminum disc cathode and a pierced anode. This tube is fitted by a ground joint to a glass deflection tube which is in turn fitted into a large bronze chamber that contains the photographic film holder and a fluorescent viewing screen. The bronze chamber has a carefully fitted door which may be opened to remove the film container, and also a pair of windows through which the viewing screen may be observed. The door has three handles fitted through it that are used for operating the film changer and for moving aside the viewing screen which also serves as the cover of the film container. The joints between



Voltage across a contact in series with the winding of an E-type relay. After the contact opens, twenty-three oscillations take place in about 450 micro-seconds

these various parts must be kept sufficiently air-tight to hold a pressure of ten microns, the normal working pressure, for a considerable period, since the pressure is very critical.

Six films about five inches square may be placed in the film container and exposed successively. After the container is placed in position, the air must be pumped from the interior of the oscillograph to allow the cathode ray to pass. The Holweck molecular

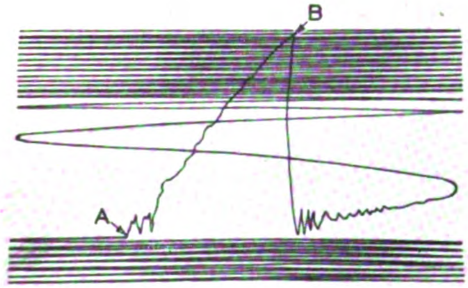


Schematic diagram of the apparatus

pump backed by an oil-immersed impeller pump will produce a sufficient vacuum in about twelve minutes. The ray consists of a stream of electrons drawn from the cathode by a potential of fifty to sixty thousand volts. Some of the electrons, moving at 80,000 miles a second, pass in a fine stream through a small hole in the anode and down through the deflecting tube. There the stream is swerved by the electric field between one or more pairs of metal plates, or by the magnetic fields of external coils, or both. Passing on down into the lower chamber, the stream generates its trace by impinging upon either a

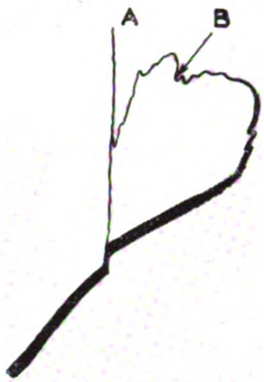
film or a fluorescent screen. A good trace may be obtained when the electron stream sweeps across the film as rapidly as one hundred miles a second.

Many different techniques have been developed for using this instrument, each particularly suited to some special investigation. The simplest one is that used for a transient wave slow enough to be shown clearly on a rectilinear time scale of the order of 5 microseconds per centimeter. This requires that the cathode stream be given a straight motion or sweep across the film at the rate of about one mile per second. It also requires that the transient be



This trace was secured by Mr. Cole's second technique. A 500 *kilocycle timing wave is swept across the film. At the instant A, a surge was applied to one pair of plates, sweeping the trace up to B. Almost instantly the voltage fell back nearly to zero. An ingenious circuit arrangement then displaced the timing oscillations to leave a clear space on the film*

precipitated shortly after the stream strikes the film. This is accomplished by a synchronous switching device built in this laboratory. A synchronous motor drives a switch which applies to the primary of a transformer a single half-wave of 60-cycle alternating current. The transformer has a ratio of 110:60,000; its secondary is connected to the cathode and anode. To the same 60-cycle source is connected a coil which, placed near the deflecting tube, will sweep the stream across the film in any desired time;



Voltage across a gap (vertically) and current (horizontally) are illustrated above. The peak (A) was reached in 0.07 *microseconds and the point B less than a microsecond later. The rest of the path was traversed more slowly*

practical limits are fifty to five hundred micro-seconds. An adjustable contact-disc on the shaft of the synchronous motor precipitates the transient just as the stream is swept across the film.

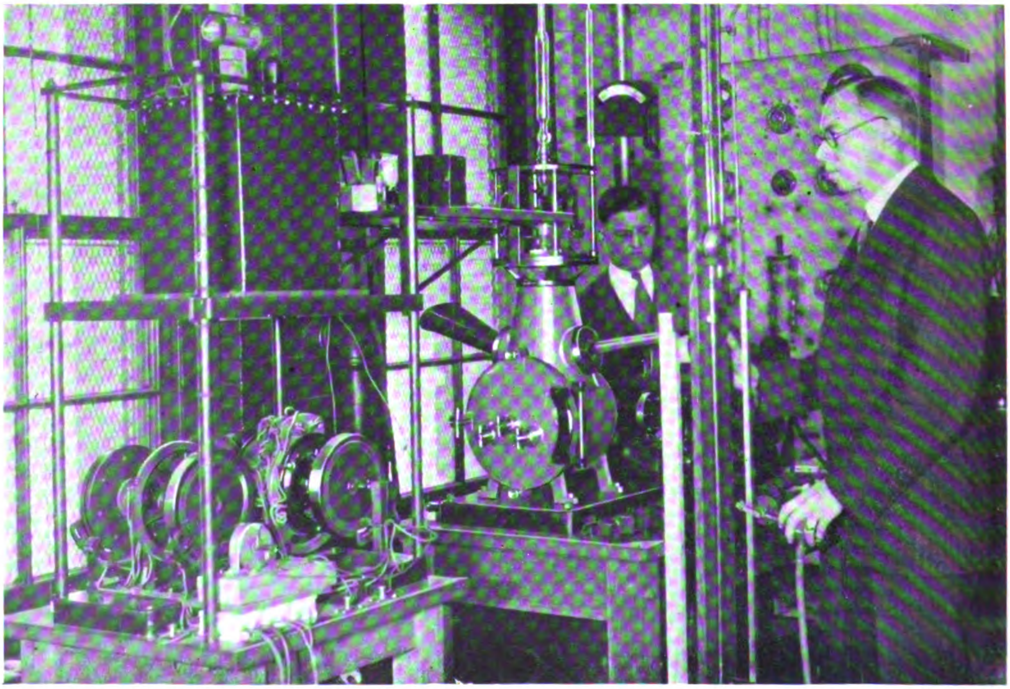
For those transients which pass too quickly to be recorded as described, the line of traversal is made, not a single straight line across the screen but a sinusoidal trace. The transient under investigation is then applied in a direction parallel to the axis of the timing wave, so that its zero line is the trace of the timing wave. Such a record appears rather involved to one accustomed to the usual oscillograms with rectilinear axes, but it may readily be replotted to the more familiar coordinates.

The timing wave commonly used in our tests has a frequency of 500 kilocycles; a half cycle then is just one micro-second.

In a study of the performance of protector blocks, we wished to obtain a curve showing the current through the protector plotted against the voltage across the gap. The starting point of such a curve was located in one corner of the film by the effect of a constant magnetic field. From this point, the stream was swerved in one direction by a coil in series with the current and in the perpendicular direction by the voltage across the gap applied to a pair of deflector plates. The resultant trace was a closed loop. Time was measured by applying a small "ripple" of 500-kilocycle current to the other pair of plates.

Another technique was used to determine the form of a transient shorter than one micro-second. The magnetic field was used to deflect the spot to the bottom of the film and a 500 kilocycle wave of about ten centimeters amplitude was applied to a pair of deflecting plates so as to cause the spot to trace a zero line along the bottom of the film. The transient was applied to another pair of deflecting plates perpendicular to the first pair and was thus plotted to a sine scale. This curve was then easy to replot to a uniform time scale with rectilinear coordinates.

Methods here described give only a hint of the uses to which this instrument may be put. So versatile and sensitive it is that it may well be described as the microscope of the electrical sciences.



Mr. Cole (right) reads the pressure gauge while A. Weller (left) adjusts the timing oscillator associated with the Dufour Oscillograph. On the table at the left is the synchronous switch and its high-tension transformer

A Brake for Rolling Ladders

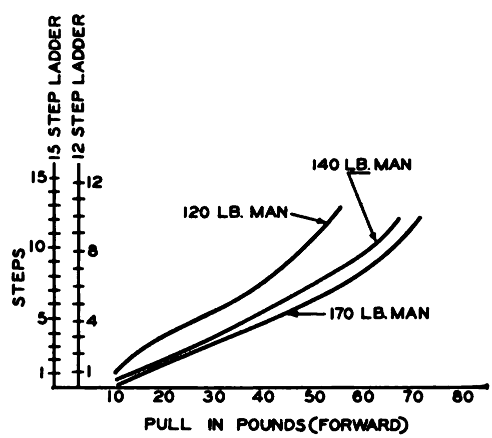
By L. N. HAMPTON
Apparatus Development Department

MOST of us have seen rolling ladders in shoe stores, where their usefulness in giving access to long upper shelves established them many years ago. In telephone offices there is a similar need of reaching high equipment, part of which extends almost to the ceiling, usually twelve feet six inches high. Slanting ladders, supported by small wheels on the floor and by a hanger rolling in a track at the ceiling, have therefore become indispensable equipment in terminal rooms.

Constant extension of dial systems has brought into greater prominence many questions about ladder equipment, for the switching frames have greatly increased the amount of central office equipment necessarily placed beyond reach from the floor. More complete standardization of ladder design and further development of trolley hangers to facilitate installation in rooms of differing height were among the first changes. At about the same time design of a safeguard to prevent unintentional movement of the ladder while in use was undertaken. Although difficulties here were greater on account of varying conditions to be encountered on the thousands of ladders already installed, such a device is now available. Its automatic operation is not only a great convenience but a valuable safety measure in addition, since it prevents the possibility of forgetting to apply the brake.

The brake, which acts on the trolley track, holds the ladder firmly while in use but at other times releases it completely without attention from the user. The brake mechanism is out of the way of maintenance men, and does not hinder their movements or their work.

At the lower end the ladders are unchanged*, but at the top they are

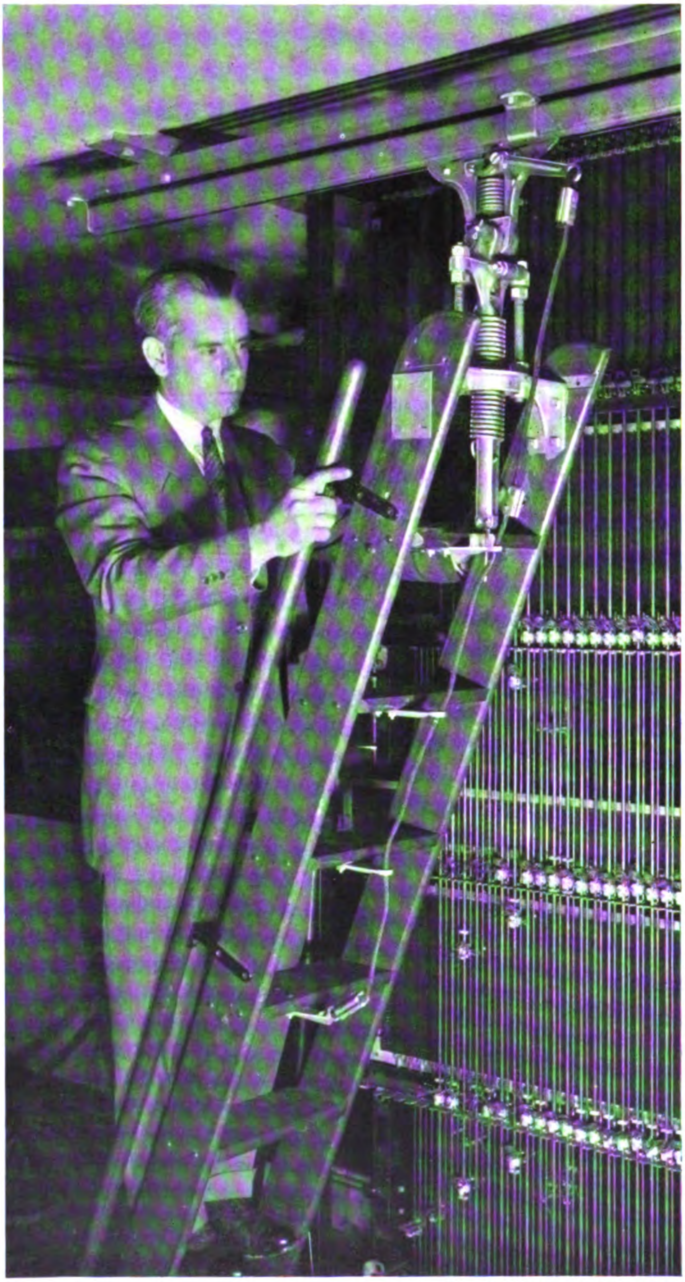


How the braking increases as the user climbs

supported by a combined hanger-and-brake assembly which, allowing vertical movement of about a half inch, applies and releases the brake as needed. In effect the mechanism makes each ladder a lever pivoted at the bottom, free to swing between limiting stops at the upper end. A coil spring on the hanger holds the ladder up when unoccupied; when a user steps on, his weight overcomes tension of the spring and pulls the upper end

* *Except for the substitution, where necessary, of wheels lubricated by grease cups.*

of the ladder down. In this movement the ladder top extends a smaller spring to which is fastened a wedge located inside the track; tension in the small spring pulls the wedge down and thereby spreads two brake shoes, pressing them against the sides of the track. These hold the ladder firmly against movement. At the end of its downward movement, the ladder top rests against a stop so that its weight is borne directly by the hanger. The force exerted by the brake shoes against the track is limited by the adjustment of the small spring, so that spreading of the track is impossible. When the user steps off, the reverse operations take place, ending with restoration of the brake shoes to their initial position.



A rolling ladder equipped with the new brake; on the step is L. N. Hampton

It might seem more direct to use a spring-controlled brake at the bottom which would support the ladder on wheels when unoccupied but drop it to the floor as soon as a user stepped on. Although such a device would be the easiest automatic brake to make and install, it was not adopted because the trolley brake gives greater protection. As a user climbs to the top the fraction of his weight carried by the upper support increases; the force available to operate a brake functioning on the track consequently increases as the user

mounts, while that available for a brake at the floor diminishes. Inherently therefore a trolley-brake increases its protection to a user as he rises to a height where such protection is desirable, whereas with a floor brake the reverse is the case. The force required to move a rolling ladder with the trolley-brake unoperated is about twelve pounds; with a man of moderate weight standing only three feet from the floor, four times as great a pull is needed to produce motion, and as he climbs the necessary pull becomes greater, thereby protecting the user and at the same time indicating to others that the ladder is occupied.

It often happens that a man at the top of a ladder finds that his work extends beyond safe reaching-distance. Here even the unprotected rolling-ladder is a long way ahead of the step-ladder resting solidly on the floor, for it can be moved along its track without the user's climbing down. That the brake may achieve its full usefulness, means must be provided for its release while the user is still at the top of the ladder. Such a release has been provided—a lever to push the wedge up against the tension of the smaller spring. A user, wishing to move the ladder, frees the brake by pulling a cord fastened to the end of the lever. He can then roll the ladder along freely while standing on it, but when he releases the cord the brake resets at once. To guard against thoughtless operation of the release cord, its lower end is fastened to a step approximately seven feet from the floor.

Control of the remainder of the block in which the Laboratories buildings are located was obtained when a lease on the property at the northeast corner of West and Bank Streets was executed December 14. *The property, which extends along West Street for* 152 *feet and along Bank Street for* 211 *feet, has been leased from John W. Morgan and Helen de Wolfe Morgan for a term ending April* 30, 2028. *This provides additional ground for the future expansion of our work that is certain to come.*

Service Honors during 1927

THIRTY-FIVE YEAR GROUP



Louis Barbieri
Wood Finisher,
Building Shop



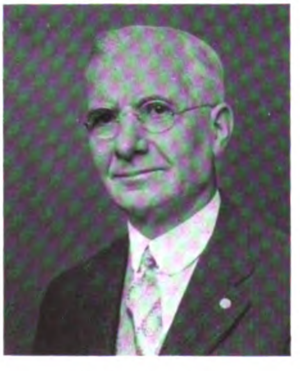
W. O. Beck
Relay Design, Apparatus
Development Department



E. P. Clifford
Vice-President



C. A. Finley
Telephone Instrument
Standards, Research
Department



C. E. Forsberg
Instrument Maker,
Research Department

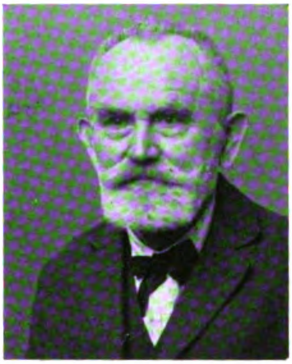


W. C. Just
Assembly Foreman,
Vacuum Tube Shop



E. R. Lundius
Circuit Design, Systems Development Department

THIRTY-FIVE YEARS



Otto Muller
Instrument Maker, Engineering Shop

THIRTY YEARS



W. C. Calmar
General Foreman, Plant and Shops Department



F. A. Cox
Installation and Maintenance Requirements, Systems Development



J. E. Devany
Laboratory Maintenance, Systems Development



H. F. Kortheuer
Manual and Toll Systems, Inspection Engineering Department



R. H. Phillips
Supervisor of Blueprint Room, Commercial Department

TWENTY
FIVE
YEARS



Thomas Barton
Elevator Operator, Plant and Shops Department



John Bickler
Pipefitter, Building Shop



C. A. Bolin
Drafting Supervisor, Systems Development Department



Bessie Brophy
Coilwinding Forewoman, Engineering Shop



Tessie Clancy
Coilwinder, Engineering Shop



E. B. Craft
Executive Vice-President



A. F. Dixon
Systems Development Engineer



C. D. Dusheck
Drafting Supervisor, Systems Development Department



J. G. Dusheck
Complaint Statistics, Inspection Engineering Department



W. C. F. Farnell
Curator, Bell Telephone Historical Museum



G. B. Joslin
Order Analysis, Systems Development Department



F. F. Lucas
Microscopic Laboratory, Apparatus Development Department



H. W. MacDougall
Patent Attorney, Patent Department



W. H. Matthies
Local Central Office Circuit Development, Systems Development Department



Margaret Meyers
Coil Winder, Engineering Shop



Edward Montchyk
Apparatus Analysis, Apparatus Development Department



J. E. Moravec
Commercial Manager and General Auditor



P. M. Neave
Reprint and Publication Distribution, Bureau of Publication



R. I. D. Nicoll
Manual Circuits, Systems Development Department



J. G. Roberts
General Patent Attorney



G. K. Smith
Step-by-Step Equipment Design, Systems Development Department



H. W. Ulrich
Manual Circuit Development, Systems Development Department



O. F. Vollheim
Heat Treater, Engineering Shop

TWENTY YEARS

C. E. Boman
K. B. Doherty
C. C. Graves
D. D. Haggerty
R. W. Harper
*Elizabeth Lorenzer**
W. E. Mougey
R. E. Noble
W. A. Schuler
W. G. Wagner
E. J. White

* *Pensioned January 18, 1927.*

New Rubber Compression Testing Machine

C. L. HIPPENSTEEL
Research Department

SINCE the Bell System uses some one and one half billion single conductor feet of rubber-insulated wire annually, its quality is of considerable economic importance. This wire is used in extending the telephone circuits from the nearest telephone cable terminal to the subscriber's premises and for house wiring. Great care must be exercised in its inspection to insure a satisfactory service life, and particularly to minimize the maintenance charges on aerial lines. A new compression testing machine has recently been developed to aid in determining the ability of the rubber insulation to meet service conditions.

Probably the two most frequent types of failure of rubber insulation are side-cutting and cracking. A tough rubber is needed to prevent them. Side-cutting is the tendency of the conductor to cut through the rubber insulation. This occurs where one wire crosses another in a twist, at an insulator or other support, when an excessive load arises. Sleet is a prolific cause of such failures. Cracking occurs at sharp bends due to a lack of flexibility of the insulation. This is caused by a deterioration of the rubber which occurs with age or from improper compounding.

Toughness and flexibility of materials are usually gauged by the tensile strength and elongation, and numerous modifications of tensile tests have been used for judging the quality of rubber insulation. However, they are of somewhat doubtful significance. It is difficult in the first place to secure representative samples, and in the second place no ordinary tensile and elongation test approaches the actual service conditions, which subject the insulation to more than simple tension.

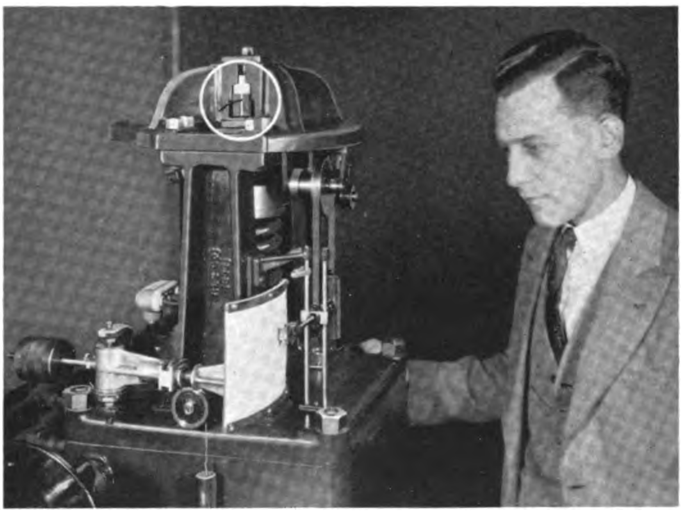
The Western Electric Company has for some time used two tests for inspection purposes as criteria for judging the ability of insulated wires to resist the types of failures which have been described as most common in the field. Ability to resist side cutting by the underlying conductor is at present determined by means of a "penetration test." In this test a taut steel wire of definite size is pressed against the rubber insulation at right angles to the conductor. Both the pressure and the time of application are specified. Establishment of electrical contact is used to indicate complete penetration of the cutting wire. To judge whether or not the insulation is too brittle for satisfactory service, it is given a wrap test. The wire, after the braid is removed, is wrapped about itself three times, left for sixteen to twenty-four hours, and rewound again in the reverse direction. The insulation is required to show no signs of rupture.

Although these tests have been of great use in judging the quality of new rubber-covered wire, they are not entirely satisfactory. Neither test affords a numerical measure of the *relative* quality of one sample

compared with another, and consequently we are unable to detect reliably samples which may be close to failure and which would probably fail after a relatively short life, owing to gradual deterioration due to aging. Another important and inherent defect of the penetration test is that the sample submitted to test is very small, being limited to rubber lying immediately under the cutting wire. Consequently, the resistance to penetration obtained may be due to local conditions which are not at all representative of the wire as a whole

The new machine designed by the Laboratories will make a test which may advantageously replace both the wrap and penetration tests. It compresses a two inch length of insulated wire, from which the outer cotton braid has been removed, between a pair of parallel steel jaws. As the rubber on the wire is compressed it assumes an elliptical form. The layer of rubber between the conductor and the jaws grows thinner as the pressure increases until rupture occurs. Means are provided for recording simultaneously the pressure and the corresponding thickness of the insulation. A frame is mounted on the machine into which may be slipped white cards about five by six inches. As the test is made a pen operated by the machine plots a stress-strain curve. The final break is recorded on the chart by a sudden drop of the needle as rupture occurs.

A unique feature of the machine which may adapt it for the measurement of small deformations is that thickness is accurately recorded mechanically on the chart with a magnification of thirty times. Until the development of this machine magnifications had not been applied to testing machines of more than three- or fourfold.



E. M. Noll testing a sample of rubber-covered wire on the compression machine. The sample is shown in the circle in the upper part of the picture

The first experimental machine, built in the Model Shop, has been on trial by the Inspection Department at Hudson Street for nearly two years. In the construction of the improved machine the Henry L. Scott Company collaborated with the Laboratories.

The new compression test gives a numerical measure (in pounds) of the ability of rubber insulation to resist cutting by the conductor. An adequate length of wire is used and the rubber is tested in place on the conductor in a way which

it is believed is closely comparable to the conditions of strain occurring in service. The tendency toward brittleness of a compound may be detected by an abnormally large thickness at break. A typical set of curves is shown as Figure 2. Curve A depicts a very distensible high-grade rubber compound. Curve B illustrates the average run of rubber compounds for aerial wire, both sides of the insulation rupturing simultaneously. In Curve C, the conductor being somewhat eccentrically located two distinct breaks are shown: first of the weaker wall, then of the stronger. Curve D is typical of a brittle compound and curve E of very soft rubber compounds and plastic or cold-flowing insulating materials. Thus from a test made on this machine much may be learned as to the character and quality of an insulating material.

Such a machine can be adapted for testing all kinds of insulated conductors and for making compression tests on variously shaped rubber specimens, or sections from such articles as tires. The outer braid might be left on the wire to give some sort of overall test if desired. Since many

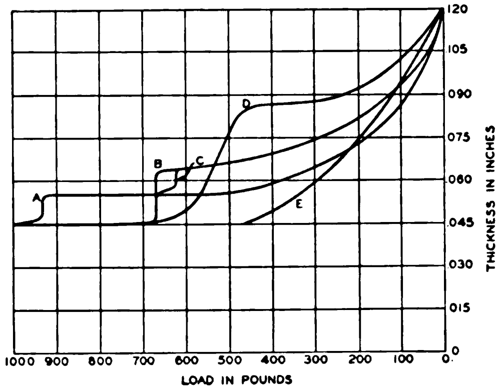


Fig. 2. A typical set of stress-strain curves for rubber insulation

structural materials, such as steel, concrete, or wood, are often subject to compressive rather than tensile strains in service, there is a possibility of usefully extending the application of the machine to a wide variety of materials.

Saving Days and Dollars With Shears

By S. W. ALLISON
Systems Development Department

IN every telephone office an adequate power plant consisting of batteries, charging generators, and their accessory equipment is an essential adjunct. In order to calculate the size of this power plant and its associated distributing leads it is necessary to know the current required to perform the various switching operations. "Current drain" studies are made, therefore, for those circuits which naturally affect the power plant. These studies provide basic information which, used with the maximum number of calls of each type that the office may be required to complete, enables the power engineer to design a suitable plant.

The "current drain" is a summation expressed in ampere-seconds of the power required to complete each call. On circuits with long holding times and comparatively few switching operations the "current drain" can be calculated from the characteristics of the relays and the known times of operation. On circuits such as the senders of the panel system, however, which have short holding times, and involve from seventy-five to one hundred and eighty relays with from two to five hundred current changes, calculation becomes difficult. Current drain data for such circuits are much more easily obtained by actual measurements which are generally made in the laboratory.

The sender is so designed that its action, once started by the removal of a receiver from a switchhook, continues automatically till a path has been prepared to receive impulses of a subscriber's dial. Following this is a delay dependent on the subscriber's speed of dialing which in turn depends on the time for searching for letters or numbers as well as the time to operate the dial. Time is an important element of the "drain" so that in artificial laboratory tests precautions must be taken to insure that the time waits and speed of dialing closely approximate average conditions. Accordingly time constants have been worked out based on observation and experiment which are accepted as those an imaginary average person would use in operating the dial.

In order that current drain tests may be made under laboratory conditions which include these accepted times, an automatic dialer was designed which will dial any desired number in accordance with these time limits. Similar devices were constructed to measure intervals equivalent to average times for operators' actions wherever these affect the holding time of the sender.

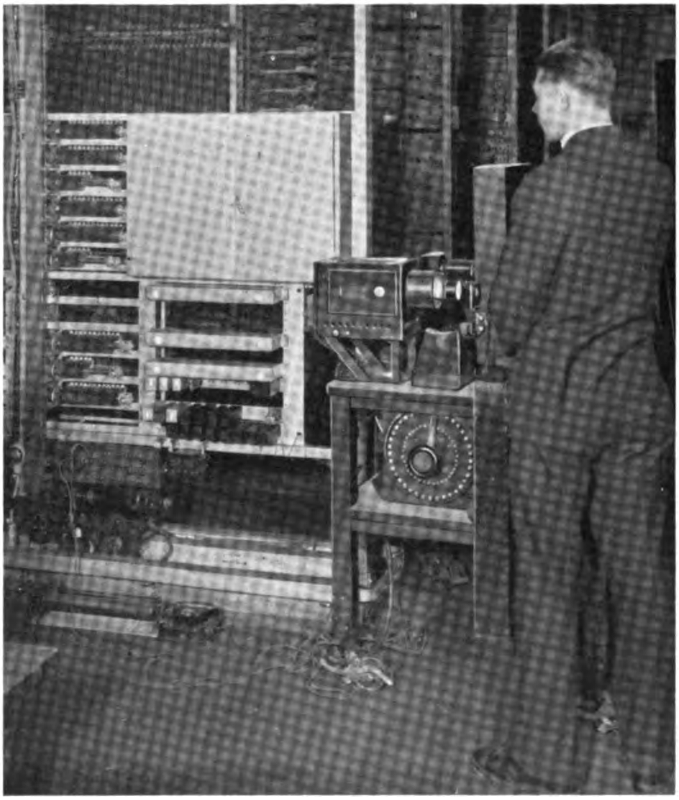
The actual "current drain" is measured with an oscillograph. The one used has three elements each of which deflects a spot of light by an amount proportional to the current flowing through its circuit. All three spots fall on a sensitized strip of paper a little over two inches wide which travels about fifteen inches per second. An electrically driven timing

mechanism marks short lines on the strip each hundredth of a second. As it is used the Number One element is left open circuited and draws a straight base line on the moving strip. The Number Three element is energized by a constant current controlled by a rheostat to give a maximum deflection and draws a line parallel to the base but near the other edge of the strip. This serves as the calibrating line because the amount of current causing the deflection is known. The Number Two element is in the sender circuit and traces a line which at all times is proportional to the sender current.

A short section of a strip from a "current drain" test is shown in the accompanying illustration with the timing marks evident along the upper edge. At the extreme right all three light spots fall on the same line. Shortly the steady calibrating current is connected and the Number Three spot rises abruptly and draws its trace parallel to the base. The second element, recording the sender current, makes its trace between the base and the calibrating line, following the actual variations of the sender current.

As the result of a single calling test which may take thirty or thirty-five seconds there is some forty feet of tape on hand with its record of current. The "current drain" is the current at any time multiplied by the time it flows. It is represented on the strip by the area between the line corresponding to the sender current and the base line. To measure this area with a planimeter is impractical because of the length of the strip. A method was devised, therefore, which requires only a pair of shears and a chemical balance.

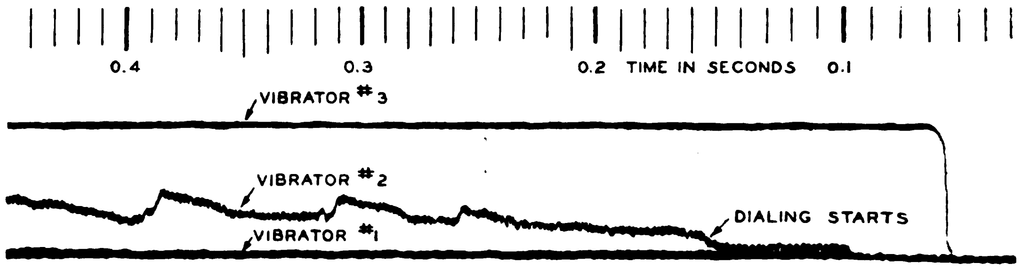
The strip is first trimmed along the base line and also along the calibrating line corresponding to the known current flow. The strip thus trimmed is then weighed. The ampere-seconds corresponding to this weight is the product of the calibrating current in amperes and the total time marked



M. G. Bailey with three-element oscillograph shown plugged into a sender circuit, ready to measure battery drains

on the upper edge of the strip. By dividing this calibrating current drain into the weight of the strip a calibrating unit in terms of ampere-seconds per gram is obtained. The strip is then cut along the line representing the variable sender current and the resulting strip bounded by this line and the base line is weighed. When this weight is multiplied by the ampere-second value of a gram obtained from the previous weighing the "current drain" is obtained for the particular dialing sequence that was used.

This method is accurate. Any variations in the thickness or weight of the paper at any point tend to offset each other as they enter both the weighings. "Current drain" data determined by this method compare favorably in accuracy with computed drain data and are obtained at a substantial saving in time and expense. The time required to complete a study on all types of calls is now a matter of days rather than of weeks.



Short section of oscillogram from an actual current drain test

For Next Christmas

To those who like to look forward to the merriment of the next winter holiday season, the Employees' Savings Plan is suggested. A very small sum deposited regularly for you will grow to a surprisingly large amount by Christmas, 1928. The Financial Department will be glad to explain the details of the plan.

The 5-A Audiometer

By L. G. HOYT
Apparatus Development Department

MOST of the large manufacturing concerns of today require a medical examination of the applicants entering their employ. One of the tests which is receiving more and more attention is a measurment of the sensitivity of the applicant's hearing. Perhaps the neglect of this test previously has been due to there being no simple and accurate way of making this measurement in definite readings for the records.

The 5-A audiometer, recently developed by Bell Telephone Laboratories, provides a means of accurately yet quickly measuring a person's hearing sensitivity and the result obtained is a direct percentage of hearing loss. At some later time, if readings are again made, the difference between this and the previous test would show the change of hearing during the interval.

The principle underlying all audiometers manufactured by the Western Electric Company is the same. A sound is generated which can be controlled in volume, and the loudness at which a person just ceases to hear it is noted. The sound, called a tone, is given out by a receiver which the person undergoing the test places against his ear. Two general types of apparatus have been used. In one the tone used is a single frequency which may be adjusted so that the sensitivity of hearing is measured at a large number of different pitches covering the range of audibility. This furnishes a complete audiogram, or hearing-sensitivity chart, for each ear. It is unnecessarily refined for many purposes, however, and so the second type was developed. In this the tone is complex — including a whole range of frequencies united in the one tone.

In one form of this latter type, a phonograph record is used on which has been recorded a series of numbers spoken with decreasing loudness. It is commonly used for school tests in which the children write down the numbers they hear. Later their papers are checked against a standard sheet. In another form the tone is generated by means of a buzzer and dry cells. The loudness at the receiver is adjusted by a potentiometer arrangement of the receiver circuit. Both of these forms lack simplicity to some extent as they depend on mechanically moving parts which may get out of adjustment, or on dry cells which must be replaced.

The 5-A audiometer departs from these methods and embodies a new principle which eliminates possible mechanical failures and the replacement of worn-out batteries. It is compact, portable, and operates on 110-volt, 60-cycle alternating current. All of the parts are enclosed in a black metal box provided with a handle for carrying, and a cover which when opened exposes the necessary apparatus to be used in making a test. It is only necessary to connect the plug of the power cord to a 110-volt alternating current supply and turn

the snap switch in this cord to put the set in operation.

The power supply is connected to a transformer having a toroidal silicon steel core with one primary wind-

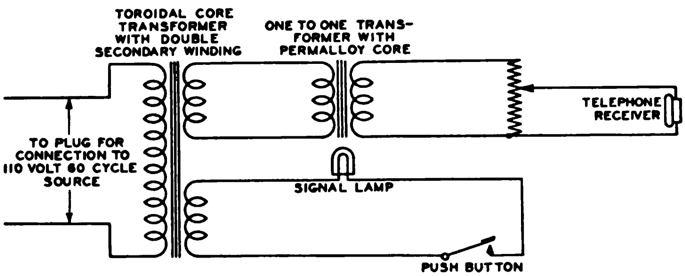


Fig. 1
Circuit diagram of audiometer

ing and two secondary windings (Fig. 1). One of the secondary windings is wound directly over the primary and supplies energy to a signal lamp. The other secondary winding is wound on the opposite half of the core so as to introduce a high leakage reactance. It is connected to a repeating coil with a one-to-one ratio winding on a core of a few permalloy laminations. The voltage delivered to this coil from the transformer is sufficient to highly saturate the permalloy core. To make the air-borne noise from the highly saturated permalloy core inaudible, the core and winding are packed in felt and placed inside a lead case which in turn is packed in felt and mounted in a cast iron box.

The electrical design problem was to convert the smooth wave of the 60-cycle power circuit to a flat-top one which, as can be mathematically proven, contains all harmonics of the fundamental. The ingenious solution, worked out by J. A. Berrian, utilizes only the two transformers already mentioned. No moving part or batteries which may need replacement are used. The highly saturated permalloy core of the one-to-one ratio transformer in conjunction with the limited current output of the power transformer with its high leakage reactance serves to flatten down the top of the input sine wave. This action can be better understood by reference to Figure 2. The dotted curve represents the 60-cycle wave of the power circuit and therefore also that of the voltage applied to the primary winding of the permalloy transformer. The current in this latter transformer follows the form of the voltage wave up to some low value "a" at which the core becomes saturated. From this point the current rises rapidly, in an effort to increase the flux above the saturation value, to the point "b," which is the maximum possible current that the power transformer, with its high re-

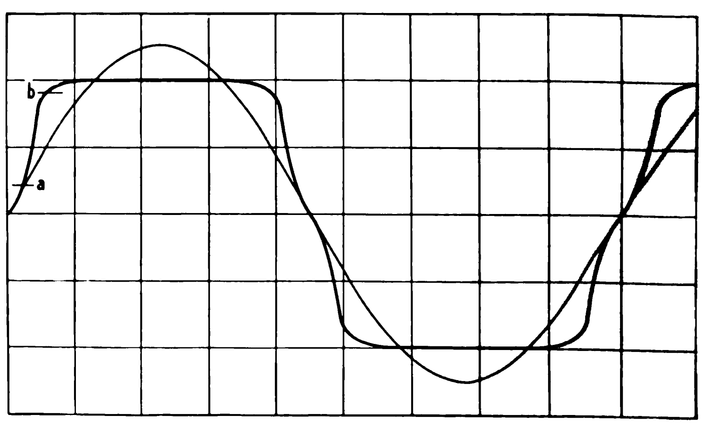


Fig. 2

actance, can deliver. It remains at this value therefore until the voltage has again dropped below the value required to saturate the permalloy core. Thus the current rises rapidly, making the steep side of the flat top wave, due to the early saturation of the permalloy core, and flattens out, making the top of the wave, due to the high leakage reactance of the power transformer.

The complex tone in the receiver may be varied in intensity in steps of five transmission units by a potentiometer capable of covering a range of 120 TU. The graduations on the scale plate of this potentiometer are in terms of percentage hearing loss so that direct readings are obtained. Minimum loudness corresponds to that just imperceptible by a person of hearing twenty per cent better than the average.

The person to be tested is instructed to hold a telephone receiver, furnished with the audiometer, snugly against one ear and to signal the operator when he no longer hears the tone. A signalling system is provided for this purpose, consisting of a button which lights a lamp in the audiometer. The person is instructed to hold the button depressed all the time a tone is heard. As the pointer of the potentiometer is slowly turned towards zero, the tone becomes fainter and fainter until a point is reached where it can no longer be heard. This fact is signalled to the operator. The setting of the pointer of the potentiometer when the tone could just not be heard is the percentage of hearing loss. It may have been on step 20 which means that the person under test has a hearing loss of twenty per cent or that his hearing is eighty per cent normal.



L. G. Hoyt and J. A. Berrian using 5-A Audiometer

It is possible that the setting for a person with more acute hearing will be 10 below zero which indicates that his hearing is ten per cent above normal. It is important that the test be made in a quiet place as external noises will result in a higher percentage of hearing loss than is actually the case.

To prevent deception by a person pretending to hear when he actually does not, a cutoff key is provided with which the operator may interrupt the tone. If this is done before the signal for failure to hear has been given but at a tone value which is actually not being heard, no notice will be taken of it by the person being tested. If he is signalling truthfully, however, he will indicate at once when

the cutoff switch has been operated.

There are other places such as schools, colleges, doctors' offices, where this audiometer may be used but the intended use is in industrial plants to provide an accurate means for determining the sensitivity of hearing of employees. It is essential in certain positions that a person have very acute hearing to perform his duties safely and efficiently and a simple test with this audiometer will prevent the assignment of a person with subnormal hearing.

A recent development of the Laboratories, the Type D single channel carrier system, played a prominent part in restoring telephone service in the New England flood area. The initial lot of terminal equipments was just being completed at Hawthorne when the flood occurred. Release was obtained from the Associated Companies for which they had been manufactured, and five were shipped to Boston on November 12, where certain modifications were made to fit the systems to the offices at which they were to be installed. Then the five systems were shipped to five different points in the flood area where each provided an additional voice channel between two telephone centers. The terminal equipments came from the factory completely tested; this as well as their compactness expedited their installation. In the emergency no work could be done on the lines to prepare them for the carrier frequencies, yet service was in all cases satisfactory.

High Voltage Storage Battery

By L. E. DICKINSON
Apparatus Development Department

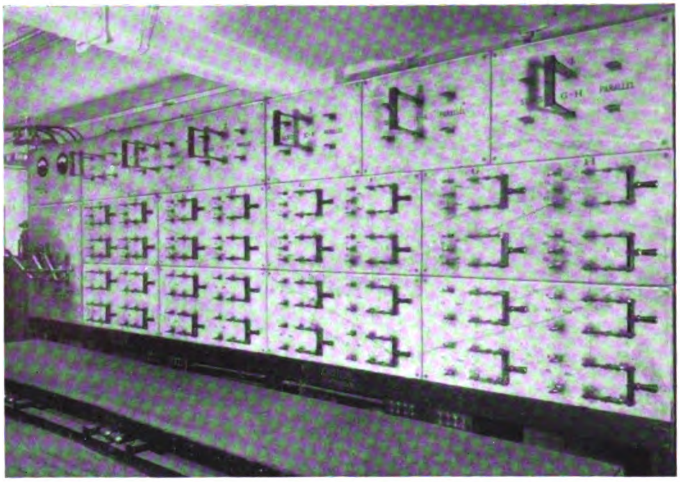
IN the development of fuses, protector blocks and other pieces of protectve apparatus for telephone use, a source capable of delivering for a few seconds direct current of several hundred amperes at high potential is extremely useful. To provide such current a storage battery is best; on account of its low internal resistance it will deliver, for the time needed to test a fuse, current at many times its normal discharge rate and at voltage very close to normal. The battery provided in the Laboratories for such testing has found use as well for investigations of resistances, electrolytic condensers and lead-covered cable. At an early stage in the development of water-cooled vacuum tubes it was used to maintain a plate potential of four thousand volts. It has even been used for magnetizing permanent magnets for loud speakers used with talking moving pictures and elsewhere.



One-twelfth of the battery. These two racks, like all the others, hold eighty-eight cells each

The high-potential battery dates from 1915, when the Electric Storage Battery Company installed 2112 cells on the first floor of the old Section H building on Washington Street. When this building gave place to the present Section H the battery was dismantled, and after overhauling was reinstalled in the room which it occupies today on the first floor of Section G. The floor, of concrete, is covered with a layer of hard acid-proof bituminous compound about an inch and a half thick, and the walls are painted with a light acid-proof paint instead of the black asphaltum paint sometimes used in battery rooms. Each cell is of sixty ampere hours capacity, and consists of thirteen lead plates about four inches square. The cells are permanently connected into groups of forty-four, and these units may be connected together as wanted.

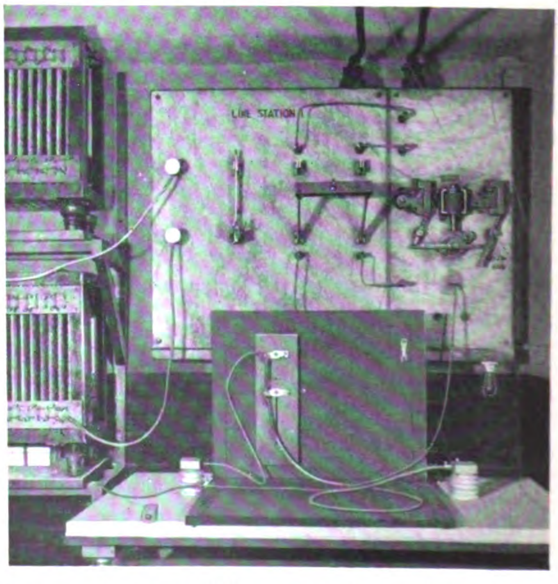
Because of the fine spray thrown



The cell groups are mounted in series or in parallel by these knife switches. At the left are the oil switches for completing and breaking connections

off by the cells during charging and of the "sweating" on the outside of the jars in humid weather, requirements are most exacting for the insulators on which the individual cells and the cell groups are supported. The wooden uprights supporting the racks of cells are mounted on double tiers of glass insulators separated by lead discs, the lower insulators resting on tile blocks set in the floor. Each group of four cells rests on a plate of wire glass ⅜″ thick, supported by small glass insulators resting on the wooden rails of the rack. Each insulator, large or small, consists of a glass body surrounded by a steep, funnel-like wall of glass; between is a circular trough filled with transformer oil. The whole insulator is protected by a lead cap, covering the top and extending down around the sides, but not touching the glass of the insulator.

Each group of forty-four cells is connected to a knife switch on the main panel of a switchboard in an adjoining room, whereby it can be connected in series or in parallel with other groups. Any voltage between 90 and 4320 can thus be obtained, in steps of 90 volts. On another panel are oil-switches by which the battery is connected and disconnected to start and stop testing, and on the third panel connections are arranged for charging. With all the cells connected in series about a thousand amperes flow during the small part of a second required for a fuse to operate. The current is correspondingly greater



Fuse ready for trial, mounted on the test table. Current is restricted to the desired value by the resistances at the left

when the battery is connected to give 540 volts. This arrangement is commonly used in testing carbon block protectors since it is close to the standard trolley voltage. In any case the circuit is opened by the oil-switches, operated manually; though a circuit breaker might be used, none has been provided, lest its operation might mask the performance of apparatus under test at the time.

From the main oil-switch, conductors of comparatively large size lead to the test table, where fuses and other protective devices are mounted during testing. Adjoining it on the left is a grid resistance for regulating the current, made up of nichrome ribbon mounted on transite cores. Sections of ribbon are connected in series or in parallel by means of small knife switches at the bottom. At the right of the table is a magnetic contactor to close and open the circuit for tests requiring currents of less than twenty-five amperes at voltages under one thousand. After the oil-switches are closed the tester presses a button which closes the contactor, and as soon as the test is finished — in a second or so—he releases it, opening the circuit. Then the oil-switches are opened. During all testing a man is detailed by the Plant and Shops Department to operate the knife switches, connecting the cell groups as wanted by the engineer making the test, and to stand near the oil-switches, closing and opening them as is necessary.



Glass insulator such as those supporting the cells and the rack

News of the Month

DR. JEWETT spoke December 1 at the seventh annual meeting of the Highway Research Board of the Division of Engineering and Industrial Research in Washington on the subject, "Engineering Research — a Retrospect and a Prospect of Scientific Investigation in Industry." On December 7 he spoke on "The Present in Engineering — 1927" at the fiftieth anniversary of the organization of the Engineers Club of Philadelphia.

MR. CRAFT addressed the Division of Engineering and Industrial Research of the National Research Council on "Selling the Research Idea" at its annual meeting, held November 18 at the University Club.

MR. CRAFT entertained Captain Ralph Earl, President of Worcester Polytechnic Institute, at luncheon and a visit of the Laboratories December 8th.

* * * *

A. R. OLPIN addressed the Colloquium on December 5 on the topic "Photoelectric Phenomena in Crystals," and on December 19 Professor L. W. McKeehan of Yale University spoke on "The Experiments and Theories of David Evans Hughes Concerning Ferro-magnetism."

RESEARCH

C. J. DAVISSON delivered an address, "Diffraction of Electrons by a Crystal of Nickel," on December 28 at the joint meeting of the American Physical Society and Section B of the American Association for the Advancement of Science held at Nashville, Tennessee. He spoke informally on the same subject at the meeting of the American Physical Society held in Chicago, November 26.

C. J. DAVISSON and L. H. Germer presented a paper, "Diffraction of Electrons by a Single Layer of Gas Atoms Adsorbed upon a Nickel Crystal," and J. A. Becker and D. W. Mueller a paper, "On Electrical Fields Near Metallic Surfaces," at the December 28 session of the annual meeting of the American Physical Society held at Nashville.

H. H. LOWRY discussed the subject "Adsorption" at the Physical Chemistry Colloquium of Princeton University on December 13.

R. A. HEISING delivered a paper on "Experiments and Observations Concerning the Ionized Regions of the Atmosphere" before the Institute of Radio Engineers on December 7.

J. W. HORTON addressed the Cleveland Section of the American Institute of Electrical Engineers, and H. M. Stoller the Fort Wayne Section, on December 15; both spoke on television.

K. K. DARROW attended the annual meeting of the American Physical Society, held December 28 to 30 at Nashville.

F. F. FARNSWORTH and C. D. Hocker visited the P. H. Murphy Company at New Kensington, Pennsylvania, and the American Sheet and Tin Plate Company at Vandergrift,

Pennsylvania, on December 5 and 6, in connection with their work on Subcommittee A-5 of the American Society for Testing Materials. At Vandergrift they observed methods of galvanizing sheet iron with zinc, and at New Kensington watched fabrication of the galvanized material.

D. G. Blattner demonstrated high-power sound reproduction on November 26 before the Amusement Park Convention, held in Chicago.

A. R. Kemp and E. M. Honan attended the meeting of Committee D-11 of the American Society of Testing Materials, dealing with rubber products, at Buffalo.

R. M. Burns returned recently from the Pacific Coast after having conducted corrosion tests on telephone cable and underground structures of telephone plant at several points there and, on the trip back, at New Orleans.

Apparatus Development

F. R. McMurry returned the end of December from Chicago, where he had been inspecting and testing models of the 15-type telegraph printer since October.

F. F. Lucas addressed a joint meeting of the American Institute of Mechanical Engineers and the Optical Society of America held in the Engineering Societies Building on December 7, on the development of high-power photomicrography.

An Exhibit at the International Radiotelegraph Conference in Washington was a set for measuring radio field strength developed in these Laboratories. It was installed in a test car of the Department of Commerce by C. C. Graves and L. F. Bockoven.

J. W. Greig retuned the one kilowatt radio transmitter at D. W. Flint's station, WDWF, in Providence, Rhode Island, early in December.

H. S. Price made surveys for installation of five kilowatt transmitters for Moody Bible Institute, Chicago, Saenger Amusement Company, New Orleans, and the University of Florida, Gainesville, during October. During November he made a survey for a similar transmitter for the Churchill Evangelistic Association, Buffalo, and early in December for a five kilowatt installation to replace the five hundred watt equipment of the Congress Square Hotel of Portland, Maine.

Since returning from South America, D. H. Newman took a vacation trip to the Pacific Coast. On the return he stopped at Chicago to make a survey for a five kilowatt broadcasting transmitter for the Chicago Daily News.

W. L. Tierney was in Tulsa, Oklahoma, early in November, making a survey for the installation in a new location of the one kilowatt transmitter owned by the Voice of Oklahoma. He later went to Philadelphia, where he retuned the transmitters of Gimbel Brothers and John Wanamaker to the new frequencies assigned by the Federal Radio Commission.

H. B. Arnold is at Cincinnati making a study of the Union Gas and Electric Company's power line carrier telephone system.

Systems Development

A. C. Dickieson conducted tests on the initial lot of Type D carrier telephone system at Hawthorne.

K. Lutomirski made crosstalk tests on the office cabling at the new Cleveland toll office.

E. P. BANCROFT has returned from San Francisco, where he had been engaged in testing picture transmission systems since July. C. E. White, who was at Chicago for the same group of tests, has also returned.

J. JULEY inspected clamps for multiple banks which are being tried out in one of the dial offices in Chicago.

B. W. KENDALL and H. H. Lowry attended the cutover of the new toll office at Cleveland on November 12, and W. H. Matthies and F. J. Scudder, the cutover of the new panel type dial office there on December 3.

V. T. CALLAHAN has been testing gas engine-generator sets at Buffalo.

A. KENNER visited Detroit early in November to discuss pneumatic tube equipment with engineers of the Michigan Bell Telephone Company.

J. L. LAREW conducted noise tests on the power plant for the step-by-step office and toll office at Utica, New York, early in November.

NOVEMBER 24 to DECEMBER 10, R. P. Jutson inspected a current supply set of new type for small toll repeater installations which is being tried out at Lexington, Kentucky.

E. J. KANE and E. H. Smith visited New London, Connecticut, during December to inspect the step-by-step line finders being installed there, one of the first such installations in the east.

D. M. TERRY visited the Brown Instrument Company in Philadelphia on November 16 in connection with a special indicating control instrument for pilot channels.

OUTSIDE PLANT DEVELOPMENT

R. L. JONES, S. C. Miller and V. B. Pike visited Allentown, Pennsylvania, with W. C. Redding, R. E. Alberts and C. Kreisler of the Apparatus Development Department and with engineers of the American Telephone and Telegraph Company, November 23 to observe the installation of a trial section of special aerial cable.

C. S. GORDON and I. C. Shafer conducted tests on protective coatings for copper wire in Boston on December 12.

R. C. EGGLESTON visited Philadelphia November 1 in connection with an investigation of eastern white cedar poles.

C. D. HOCKER and W. A. Hyde visited the plant of the General Electric Company at Lynn, Massachusetts, on November 26.

L. W. KELSAY visited New Haven and Hartford during the latter part of November, making investigations in connection with terminals for underground cables.

C. D. HOCKER was in Pittsburgh on December 5 for committee work of the American Society for Testing Materials.

E. ST. JOHN visited the plant of the Bethlehem Steel Company at Lebanon, Pennsylvania, on November 30 for investigations on interchangeability of certain threaded parts of outside plant hardware.

J. A. CARR examined sections of the aerial cable between Goshen and Liberty, New York, with engineers of the American Telephone and Telegraph Company on December 13, to obtain data on the cutting of cable sheath by aerial cable rings.

INSPECTION ENGINEERING

G. D. EDWARDS, D. A. Quarles, W. A. Boyd, H. G. Eddy, H. F. Kortheuer and R. M. Moody represented the Laboratories at a confer-

ence held at Hawthorne during the week of Novembr 28 regarding the schedule of Survey Conferences for 1928.

O. S. Markuson, R. M. Moody, H. G. Eddy, and P. S. Olmstead attended regular Survey Conferences at Hawthorne during November and the early part of December. R. M. Moody and H. F. Kortheuer attended similar conferences at Kearney.

G. D. Edwards visited the Field Headquarters at Chicago and Cleveland during the first week in December.

R. J. Nossaman visited the headquarters of Local Field Engineers at Cleveland, Chicago, St. Louis and Omaha during December.

P. B. Almquist, Local Field Engineer at San Francisco, was in Los Angeles the first week in December for regular field work.

S. C. Miller and E. G. D. Paterson visited the Whitney-Blake Company in New Haven on December 16 to discuss problems connected with the manufacture of telephone wires.

E. F. Helbing observed the operation of a six cylinder type "T" Foos gas engine installed in a new step-by-step office in Utica, New York.

Patent

H. A. Burgess, E. V. Griggs, J. A. Hall, W. C. Kiesel and M. R. McKenney visited Washington during the period from November 10 to December 12 for the prosecution of applications for patent.

General Staff

S. P. Grace delivered a lecture on developments of the Laboratories, particularly those dealing with speech and hearing, to the twenty-third annual convention of the Illinois Telephone Association at Springfield, Illinois, on November 18.

At a conference on personnel relationships conducted by men from fields of education and business, John Mills spoke on "A Mutual Requirement for an Employer and an Employee." The group met on November 16 at the University Club, Boston.

R. W. King described television apparatus and its operation to the Cincinnati Section of the American Institute of Electrical Engineers on December 8.

M. B. Long spoke on television before local sections of the American Institute of Electrical Engineers at Boulder and Denver, Colorado, and at Lincoln and Omaha, Nebraska, the middle part of November.

L. S. O'Roark spoke December 20 to the Louisville, Kentucky, Section of the American Institute of Electrical Engineers on recent developments of Bell Telephone Laboratories, particularly television. That afternoon he spoke on the same subject to a student group at Speed Science School.

E. U. Condon spoke November 17 to the physics colloquim at Princeton University on "Recent Advances in Knowledge of the Hydrogen Molecule," and to the physics department meeting at Columbia University on the same subject December 2.

J. S. Hartnett, A. J. Daly and D. R. McCormack visited Hawthorne recently to discuss various commercial matters.

R. A. Deller gave a group of lectures on television at Ohio colleges, December 12 to 17, speaking at Wooster College, Denison University, Ohio, Wesleyan University, Ohio State University, and Oberlin College.

Club Notes

On Monday, December 19, when more than 3500 members of the Laboratories expressed their choice by ballot, Donald A. Quarles was elected president of the Club for the coming year, George F. Fowler first vice-president and Marie Boman second vice-president. S. James Stranahan will represent the Apparatus Development Department during the next two years, and Thomas C. Rice the Patent and Inspection Departments. The Plant Department is to be represented by George Rupp. The new terms start at the January meeting of officers and departmental representatives.

Winter Dance

The orchestra has now been engaged for the Club dance — Don Marcotte's Vagabonds, whose playing as broadcast by station WEAF has been so popular. Those who have not yet bought their tickets are urged to avoid disappointment by securing them at once from departmental representatives, since the number of tickets has been limited to prevent crowding. Tickets for box seats should also be bought immediately, since only a hundred and eighty are available. The dance is to be held in the Hotel Pennsylvania, as announced before, on Thursday, February 2; dancing will start at nine, and will continue until two. Tickets are $1.10 each, and box seats $1.65 each.

Chess

Our team in the Commercial Chess League of New York has still to find a team that can break its string of victories. Having won the Commercial Championship for four successive years our players are now on their way to a fifth championship. This season they have won all five of the matches played so far and have only lost one game out of twenty played. In previous seasons five or six men have carried the burden of these matches but this year our players were markedly better, and ten of them took part in league games.

We are especially proud of the fact that our team defeated by a score of 3½ to ½ that of Western Electric, one of the strongest teams in the league. The Western Electric team is composed of the best chess players that can be found in the various branches of the Western Electric Company in the metropolitan district.

Picture Contest

Since the Picture Contest is to be held in February, it is quite time for intending participants to get busy. The extent and excellence of last year's exhibits surprised everybody, and this year the contest should be even better. Sheets telling of the classes of pictures and all conditions of the contest will be sent to everybody within a few days.

Golf

Sixty players took part in the indoor golf tournament, the first of the season, held December 12 at the

Vander-Built-In Golf Course. So great was the interest that another tournament has been scheduled for the same place January 25, and plans for a March tournament are under way.

In the qualifying round, divided into two groups, R. Koernig and F. B. Blake tied for first place in Group 1 and divided the prize. In Group 2, E. J. Johnson carried off the medal prize with a score of 79, the lowest of the evening.

The finals brought out some excellent golf, and some disappointments as well. In Class A, Group 1, R. Koernig beat W. H. Harvey on the eighteenth hole after a round of heart-breaking golf. In Group 2 of Class A, F. D. Smith, a man who promises our golfers keen competition in future contests, won from E. J. Johnson. L. G. Hoyt was the winner, for the third consecutive tournament, in Group 1 of Class B; Group 2 of this class was won by W. C. Burger, who eliminated G. E. Kellogg, one of our star golfers. E. H. Chatterton defeated D. D. Haggerty in Group 1 of Class C, and H. L. Downing won from R. E. Merrifield in Group 2, after Mr. Merrifield had played thirty holes to win the semi-final round. In Group 1 of Class D, A. I. Crawford won from D. A. Danielson on the eighteenth hole, and in Group 2 I. R. Goshaw defeated H. Leicht.

Hiking

Though the fall hikes are now only pleasant memories, the records show enthusiastic participation on the part of the members. R. W. Bogumil is first in the distance covered, 146 miles, and W. C. Buckland and F. R. Stansel are next with 134 miles and 112 miles respectively. The men are not the only walkers, though—Phyllis Barton also hiked 112 miles, in spite of the fact that sickness kept her from some of the hikes. Evelyn Brisbane, 107 miles, is second among the women, and Elizabeth Mains, 95 miles, third. In addition, Margaret Brisbane has qualified for the 75-mile hiking emblem of Bell Laboratories Club.

Women's Club Activities

Dancing

The holiday rush had its effect on the attendance of the dancing class as on many of our other regular activities, but those who continued with Mr. Vecchio found the class as enjoyable and invigorating as ever.

Conforming with the present popular demand for Spanish dances, Mr. Vecchio has been spending quite a bit of time recently on various steps of the Tango. Just what the class will specialize in during the next ten lessons will depend on the wishes of the girls who sign up in the class now forming.

Women's Bridge Club

In the first tournament of the Women's Bridge Club, completed last month, the highest score, 5509, was made by May Lynch, who also carried the honors for having the highest score for one evening, a plus score of 2002. The two next highest in the tournament were Virginia Crim with a score of 3770 and Elizabeth Pritzkow, who made 2968. There were thirty-one players, most of whom intend to continue to play on Tuesday evenings in the Women's Rest Room. Others wishing to participate should call Katherine Munn.

Swimming

The new classes begin on the ninth

and the eleventh of this month at the Carroll Club, and presumably will be as popular as ever. Those interested can get full information from Eleanor Bolan.

Bowling

A bowling club will be started if enough women are interested. Some have said already that they would join. Others who wish to participate should communicate with the new Second Vice President.

Christmas Poster Contest

There were fifteen posters submitted in the Christmas contest, all well worth the attention of the judges. Several were so good that it was with difficulty that a choice was made. After thorough consideration the judges picked for reproduction and display on the bulletin boards the poster prepared by Alice Pease, and awarded to her the ten dollar gold piece offered as prize. Honorable mention was given the poster designed by Fred Frampton.

Final Standing in Bell System Basketball League

1927 Season

Total Points Scored

Team	Points
Bell Laboratories	222
Long Island	209
Hudson Street	197
Headquarters	182
Southern Manhattan	179
Installation	157
Westchester	152
Northern Manhattan	93

Final Standing

Team	*Won*	*Lost*
Bell Laboratories	6	1
Long Island	5	2
Hudson Street	5	2
Headquarters	5	2
Southern Manhattan	3	4
Westchester	3	4
Installation	1	6
Northern Manhattan	0	7

Points Scored by the First Twenty Men

No.	Player	Points
1.	Abruscati, Installation	74
2.	Hasior, Bell Lab.	57
3.	Maurer, Bell Lab.	54
4.	Stevens, Headquarters	54
5.	West, Long Island	53
6.	Hickey, Hudson Street	52
7.	McFarland, Long Island	50
8.	Burkhard, So. Manhattan	44
9.	Cronkite, Hudson Street	37
10.	Gittenberger, Bell Lab	37
11.	Dittmar, Headquarters	36
12.	McGeeny, Long Island	35
13.	Rossi, Hudson Street	34
14.	Bedingfield, So. Manhattan	34
15.	Booth, So. Manhattan	33
16.	Steinmetz, Bell Lab	32
17.	O'Neil, Bell Lab	32
18.	Gunderson, Westchester	32
19.	Redmond, Westchester	31
20.	Bobenreith, Long Island	31

BELL LABORATORIES RECORD

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By R. A. Heising

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By J. R. Townsend

USE OF CODES IN COMMUNICATION
By J. L. Hogg

FEBRUARY 1928 VOL. 5 NO. 6

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Bell Laboratories Record

Volume Five FEBRUARY, 1928 *Number Six*

Ionized Regions in the Atmosphere

By R. A. HEISING
Research Department

WITH the first transmission of radio signals across the Atlantic, a phenomenon was demonstrated which previously had been considered impossible. Electromagnetic waves of all kinds travel in straight lines unless deviated by some unusual condition, and so it had been considered impossible to transmit radio signals over long distances, because of the curvature of the earth. Success of the transatlantic transmission showed however that unless there were other elements entering into the transmission conditions than those previously considered, the theory of straight-line travel was wrong. Attempts were made to account for success of the transmission on the basis of atmospheric refraction, dispersion, and the effect of a conducting ground, but none of these explanations was entirely satisfactory. In the meantime it was suggested that the cause might be reflection* from an ionized region in the atmosphere. This suggestion was first made over twenty years ago, but it is within the last few years that the ionized zone has been shown as the real cause of the transatlantic success.

To determine the existence of reflection from such an ionized medium, efforts were made to observe it by the most direct method possible. For such observations radio waves were transmitted from the Laboratories' experimental station at Deal, New Jersey, to a receiving laboratory forty-seven miles away, near Mineola, Long Island. If there were a reflecting layer in the upper atmosphere, a second path for the waves would be available, much longer than the direct path along the ground, and signals traveling over the reflected path symbolized in Figure 1 would take longer to arrive than those using the direct course. Hence reception of primary signals and then, a trifle

* *When a wave enters a medium in which its velocity of propagation varies from point to point, its direction of advance becomes curved. If the change of velocity is rapid enough, the curvature is so abrupt that the effect is much the same as that of reflection from the surface of the medium. It is often convenient to speak of this phenomenon as reflection, although it is really one of refraction. How radio waves are supposed to be bent was shown graphically on pages* 349-353 *of the* RECORD *for June,* 1927.

later, of auxiliary signals would be evidence for the existence of such a reflecting layer. From the time interval between original and auxiliary

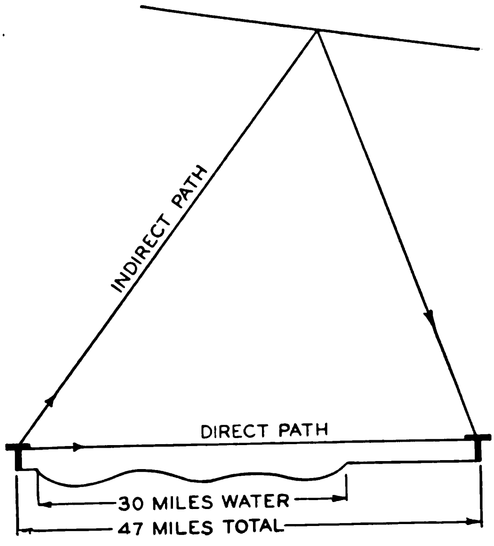


Figure 1

signals the difference in length of the paths could be computed.

Signals of the type shown in Figure 2 (A) were transmitted. High-frequency power was radiated for periods of approximately 0.001 second at intervals of about 1/60 of a second. Signals similar to Figure 2 (B) were received with a sharply tuned set, and were recorded by an oscillograph. When there were two paths for transmission of the wave — a path with reflection from an overhead layer in addition to the direct path along the ground — two signals were received for each group of waves transmitted, as represented in Figure 2 (C). This is strong evidence for the existence of the postulated zone of ionization. Drawings of the oscillograms of actual received signals are shown in Figure 3.

Even more than two paths were sometimes observed. Some of the paths would occur as represented in Figure 4, where paths **B**, **C** and **D** have one, two and three reflections respectively from the reflecting layer. The diagram at the right of the drawing shows the type of signal to be expected under such circumstances. As many as four signals may be received for each signal sent. Oscillograms in which signals arrived by several different paths are represented by Figure 5.

The theory of the reflecting layer requires the presence of free electrons. When an electromagnetic wave traverses this reflecting region the unattached electrons are moved by the influence of the wave and absorb energy from it. On account of their mass and charge and the presence of the earth's magnetic field the electrons in their movements reradiate the absorbed energy slightly out of phase with the passing wave; in doing so they change the effective velocity within the refracting zone. This variation in effective velocity is, of course, the cause of refraction.

The electrons in this reflecting layer are supposed to come from two

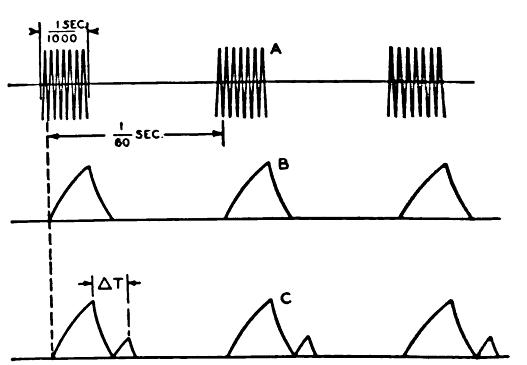


Figure 2

sources. There is good reason for believing that electrons may be shot out of the sun and reach the earth. Other electrons are freed by ultra-violet light from the sun, which, on reaching the atmosphere, knocks off electrons from molecules of its gases. It appears from our experiments that the free electrons in the ionized regions of the atmosphere are produced by both of these causes; electrons from the sun spots are received both day and night, since their paths are bent by the earth's magnetic field, while ionization of the air molecules takes place on the sunlit side of the earth.

The free electrons do more, however, than refract or reflect the waves. When an electron absorbs energy from a passing wave and executes an oscillatory or circular mo-

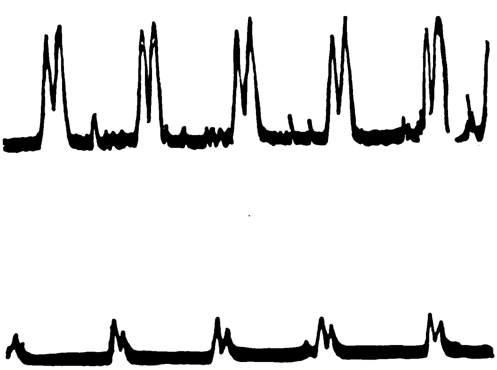


Figure 3

tion in the atmosphere in its absorbing and radiating process, continuance is insured only as long as nothing gets in the way. If there are many gas molecules around, the moving electron may strike one and lose a large part or all of its energy, or it may be deflected in such a way that the energy remaining is radiated at random, no longer contributing to the passing radio wave. In such a case the free electron must absorb more radiation before it can contribute fur-

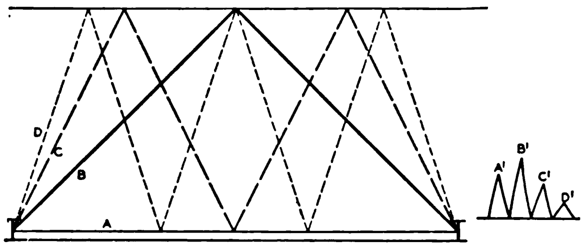


Figure 4

ther to the passing wave. The presence of gas molecules in the region where the free electrons occur thus causes absorption of energy from the wave. Under these circumstances the wave may be so reduced in intensity that it is worthless for radio purposes.

It has been shown in a paper by Nichols and Schelleng* that the frequency of collision with molecules is related to the magnitude of absorption. If the gas molecules are relatively close together — if the air is dense — a free electron can scarcely move under the influence of a passing wave since the gas molecules block its way, and so neither absorption nor reflection occurs. If the gas molecules become less numerous the free electrons can move more readily. At a certain air density therefore maximum absorption occurs, because at that stage it is certain that practically all the electrons lose their energy by collision with gas molecules before they have had a chance to radiate again any appreciable part of it. As the density of the gas is still further reduced the molecules become so far apart that the electrons can execute a great number of oscillations before losing their energy by collisions.

* *Bell System Technical Journal, April,* 1925.

Density of the air thus determines location of the zones at which waves are absorbed.

Atmospheric density is greatest at the earth's surface, and rapidly becomes less as the altitude increases. At a height of about fifty miles the



Figure 5

density is reduced to the value causing the greatest absorption, and about twenty-five miles higher is so much less that the electrons can execute their oscillations with only rare loss of energy to the gas molecules in collisions; reflection, or more properly refraction, can therefore occur. That region where the air density is suitable for absorption is called the "absorbing region," while the zone higher up in which refraction occurs is called the "refracting region."

When an electromagnetic wave travels between two points separated by a considerable distance, on account of the earth's curvature a wave received at a distant point must have travelled up to the refracting region, and there have been turned downward to strike the earth at the receiving station. The wave must therefore have passed through the absorbing region twice. On the way up, if many free electrons are present in the absorption region the energy of the wave may have been so cut down that little is left to be reflected, and after reflection it will be cut down further on the return to earth. Long distance radio communication can therefore be secured only by means of those waves which can make two or more passages through the absorbing zone without undue attenuation.

The experiments appear to support the hypothesis that free electrons are produced in the absorbing region of the atmosphere by ultraviolet light from the sun, making absorption thus a daylight phenomenon. It is not equivalent for all radio waves, but varies with the wavelength. At 15 to 20 meters it is very small, is fairly great for wavelengths around 100 meters, and is a maximum just over 214 meters; beyond this point it seems to become much less.

The free electrons present in the refracting region at night appear to be those which arrive from the sun. There are also some "hold-over" electrons formed during the day and remaining uncombined with the positive gas ions. The electrons from the sun appear to be more numerous or at least more influential, for the data show that the refracting region moves up and down in a manner not compatible with other hypotheses. The apparent height of the refracting region at night is from 150 to 400 miles. During the day, the larger part of the free electrons in the refracting region are caused by ultraviolet light from the sun. Since this light produces free electrons at altitudes as low as 16 miles, the apparent height of the refracting region is much lower by day than by night.

From our observations, we have concluded that the refracting region does not remain in any position, but

moves up and down. A rise of six miles per minute and a fall of twenty-five miles per minute were observed. This rapid movement of the refracting region at night appears to be the cause of rapid fading of those wavelengths which travel well at night. If the reflecting or refracting layer were fixed and the frequency of the transmitting station fixed also, fading would not occur, but because the refracting region is moving, fading is produced.

Another effect is bad quality of received signals under certain conditions, as has been proved by Bown, Martin and Potter.* When the reflected wave as received is of the same order of magnitude as the wave which comes along the ground and when frequency of the transmitting station is not constant, the signals arriving at any receiving station over two paths will actually be of different frequencies. Travelling over different paths, two or more waves arriving simultaneously will have left the transmitting station at different times and if the carrier-frequency of the station is not constant the waves will be of different frequencies. If the two waves are of the same order of magnitude a beat note will result. For the large number of frequencies in a modulated wave, the correspondingly large number of beat notes results in noise which overshadows the speech or music being received. Experimental demonstration of this phenomenon is shown in Figure 6. Power of constant amplitude but of varying frequency was radiated from the transmitting station during the transmitting intervals; at the receiving station, the beats between the waves arriving over the two paths produced the distortion shown. Any transmitting station therefore operating with variable frequency may be expected to produce bad quality at all receiving stations to which there is more than one path of transmission. It is for this reason that the greatest care is taken in the design of modern broadcast stations to prevent variation of the carrier frequency during the course of an audio wave.

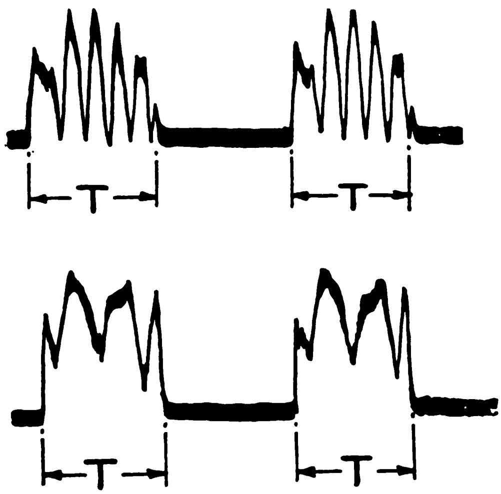


Figure 6—A wave of varying frequency, when received over two paths, gives rise to the beat notes indicated

* *I. R. E. Proceedings, February,* 1926.

New Specifications for Raw Materials

By J. R. TOWNSEND
Apparatus Development Department

STUDIES of the properties of materials have been made in the past, but with the increasing complexity of the telephone plant these studies have had to be carried forward to greater detail in order to set up more precise standards of quality. Furthermore, the growth of the Bell System requires vast quantities of materials, and much depends upon the steady flow of materials of the proper quality and uniformity into the manufacturing plants.

The raw materials used in telephone apparatus are controlled by specifications which depend upon the basic physical qualities of the material

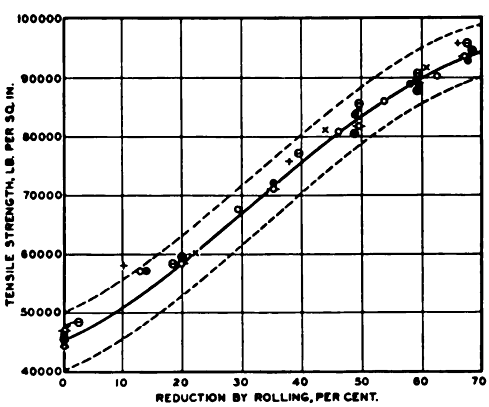


Fig. 1—How rolling increases the tensile strength of brass sheet. The points symbolize tests on different thicknesses

and the requirements of manufacture. Within the last few years a new series of specifications has been inaugurated by the Laboratories to cover those raw-material requirements that are of engineering concern. More than a score of these specifications have been issued; they cover such diverse materials as wax, duralumin, powdered permalloy, silk, cable sheath, lubricating oil, and sheet brass. The new specification series is designated as "LRM," that is "Laboratory Raw Material" specifications. It is intended that all the important materials used in telephone apparatus shall be covered ultimately by such specifications. They serve to collect, and state precisely, all the engineering information necessary to secure material of the proper quality. The Western Electric Company uses this engineering information in the preparation of purchase specifications.

In preparing "LRM" specifications considerable care is taken to see that the quality of the material is correct from an engineering standpoint. Economic considerations such as sources of supply and commercial grades are also considered. The requirements are submitted to the Western Electric Company in order that questions of mutual interest in the production of telephone apparatus may be considered, and that the requirements after study from a commercial viewpoint will be entirely acceptable to all concerned. In important cases a joint study is made of raw materials covering the manufacturing history and physical properties as a basis for specification work.

A striking instance of such an in-

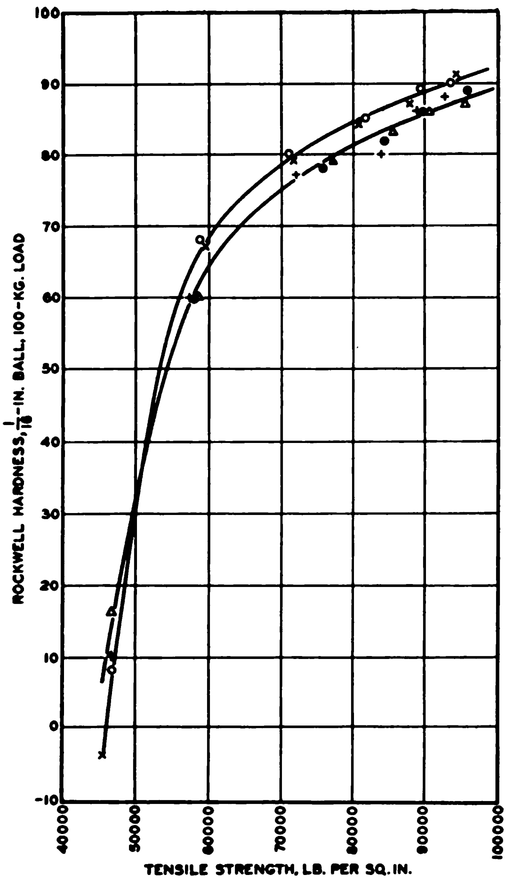


Fig. 2—*That a relation exists between tensile strength and Rockwell hardness numbers is indicated by the narrow distribution of points. The curves are for sheets above and below* 0.040 *in. thick*

vestigation is that made by the Western Electric Company, the Northern Electric Company, the American Brass Company and the Laboratories which led up to the new specifications for non-ferrous sheet metals These materials — brass, phosphor bronze, nickel silver, and the like — are widely used in all sorts of apparatus. They must be capable of fabrication in various ways to produce apparatus parts having resistance to wear, bending, torsion, vibration, corrosion, and so forth. Some of the essential physical properties desired — ductility, tensile and compression strengths, hardness, elastic and endurance limits — can be measured with great accuracy. Some can be correlated with others, as for example endurance limit with tensile strength and again hardness with tensile strength. A complete tensile test will give many of the essential mechanical properties of sheet metals. However, for the inspection of raw materials, this test leaves much to be desired: a piece has to be cut from the stock, milled to size, and destroyed by the test itself. The test for hardness can be made on the raw stock, and is not destructive. If then a satisfactory test of hardness could be found, and correlated with the results of tensile tests, much time and expense would be saved.

One measure of the desirability of a testing method is its reproducibility — that is, whether or not it can be depended upon when applied by different observers using different instruments. This point is particularly important in inspection testing, where the work is done in separate places.

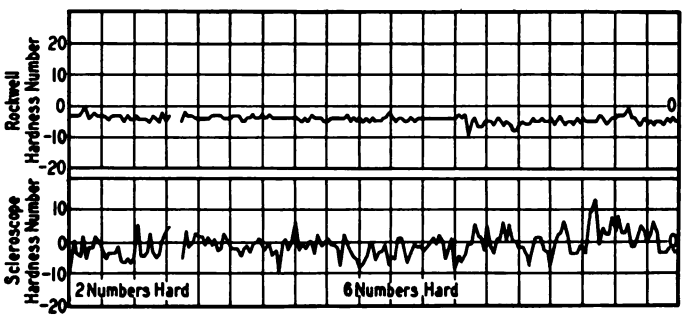


Fig. 3—*Variation between readings by two independent observers. The smoother curves for the Rockwell instrument indicate its superior uniformity*

The method of attack on the problem of non-ferrous metals was to have the Brass Company prepare sample lots of sheet metal, as, for example, sheet brass, rolled to various thicknesses and hardnesses. The rolling was done in a commercial manner, but very careful data were obtained of the actual conditions surrounding the manufacture of the metal. Complete physical tests were made in the Laboratories upon these samples, and the data were sent to all collaborators. These tests confirmed what had long been felt, that the scleroscope test of hardness as formerly specified did not give sufficiently precise results when used under inspection conditions. This test has therefore been eliminated from our specifications. A close agreement however was found between the Rockwell hardness numbers and tensile strength. This is evident from the uniformity with which the points of Figure 2 lie along one or other of the smooth curves. Furthermore, Rockwell hardness numbers as determined on five different instruments showed that the various inspection results of producer and consumer could be expected to agree.

With the data from the laboratory tests and from previous work and from experience with actual shipments of material, requirements were drawn up for non-ferrous sheet metals. It was determined that at the present time the best means of specifying the quality of these metals is the tensile test. In the new specifications this is given as the basic test and the Rockwell hardness test is used for inspection since it is non-destructive and easy to apply. In case of doubt as to whether the material fulfills the requirements, a tensile test is made. The Rockwell test is specified for all thicknesses of sheet brass down to 0.020 inch. For thinner material, a tensile test is always made since the Rockwell test is unsatisfactory here.

As part of its responsibility in the design of apparatus, the Laboratories select appropriate raw materials, whose quality they define in terms of precise tests. This care, exemplified in the specifications for non-ferrous sheet metals, is one of the Laboratories' contributions to uninterrupted telephone service.

An Appreciation of Achievement

"The outstanding experimental result of the year has come from a continuation by Davisson and Germer of the (electron) scattering experiments using a single crystal of nickel. . . . It should be noted that these electron scattering experiments involve a difficult technique; and, because of the several independent variables, the amount of data required is very great. It seems safe to predict that these preliminary results may make a new era in atomic physics. . . ."

—From the report of the Committee on Progress in Physical Optics in the Journal of the Optical Society for January, 1928.

The Use of Codes in Electrical Communication

By J. L. HOGG
Research Department

THE subject of codes is of fundamental importance in many forms of electrical communication. Even the sounds of speech may be considered as the characters of a code into which we are taught from childhood to translate our thoughts.

Proper choice of the variations of electric current which are arbitrarily assigned to represent the symbols of speech and writing aids greatly in realizing the full transmitting efficiency of any particular system. It does not always happen, however, that the communication engineer is at liberty to substitute one code, which might theoretically be better, for another already in use. It would scarcely be practicable, for instance, to undertake to alter the code commonly designated as speech although it is perfectly true, as will be brought out later, that codes are known which, with given line facilities, will transmit words a great deal faster than they can be transmitted by the voice. Much more meaning is conveyed by the voice, however, than is represented by the words alone. Manner of speaking, inflections, and pauses for emphasis, frequently tell more in a fraction of a minute than would hundreds of words.

Leaving speech as something which it would scarcely repay us to attempt to alter, at least for the present, we shall see upon a little inspection that in the matter of artificial codes there is much room for choice. This brings us at once into the domain of the telegraph.

Unlike the sounds of speech, telegraph code characters may be selected at will with only efficiency as a criterion. To originate code signals, a mechanism produces abrupt changes in the voltage applied to the sending end of the line. In the case of the familiar Morse code, the units are distinguishable from one another by their varying duration. In the Continental form of this code, there are three standard time intervals, the lengths of which are as 1 :3 :5. Application of one pole of the battery to the line for these different intervals communicates what are called the m a r k i n g units, the dots and dashes. Removal of the battery or the application of the other pole to the line sends out the spacing units, the letter spaces and word spaces.

In telegraph communication, it is necessary to transmit fifty-odd characters. The time taken to put on the line the longest character of the Continental code is twenty-three times a dot length. To put the shortest character on the line four dot lengths are required, one unit of time for the dot itself and three for the letter space to follow.

One may now venture the guess that this particular code is rather wasteful of line time. Any change in the characters would be desirable which would shorten to the minimum the time required to put onto the line the character of average length. One

apparently plausible method is to use a variety of sending battery voltages — these to be allocated in a definite manner among the code characters — instead of relying solely upon different durations to effect discrimination. There is a fairly definite limit, however, to the number of discrete voltages that can be employed in practice, the most important consideration, perhaps, being that it obviously increases the complexity of both sending and receiving apparatus.

Having once decided upon the combinations of current pulses which are to form a code, the possibility obviously presents itself (provided these combinations are of different length) of assigning them among the letters and other characters so that those used most frequently will also be those requiring the shortest time to send. Studies have been made of the relative frequencies with which the various letters occur in the English and other languages. With the results of such an analysis at hand, it is easy to set up an economical assignment of code characters to alphabetical characters. The commonly-used codes leave little to be desired in this connection.

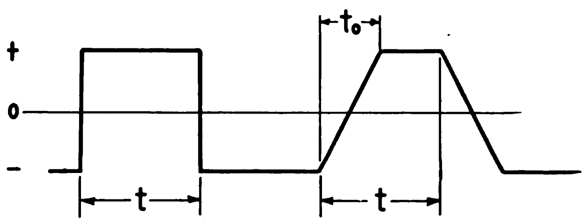


Figure 1 *Figure* 2

For simplicity in this and the other drawings straight lines are used which show the principal part of the sluggishness in current change though true representations would show the corners decidedly rounded

Choice of code characters, most economical in terms of transmission speed or line time, is not by any means so simple a problem, however. It depends in large measure upon the characteristics of the terminal and line apparatus, and practical experience is usually the best guide to the final choice.

Such a code as the Morse, the time lengths of whose characters are not all equal, is well adapted to manual sending and aural reception, but for printer operation mechanical advantages are gained by making the characters all of equal length. A common form of printing telegraph code (it is used by the system developed some years ago at our Laboratories) has a common length of five dot lengths* for each character. This provides thirty-two different current pulse combinations, a number just about doubled by providing that two of the thirty-two characters act in a manner analogous to the carriage shift keys of a typewriter. It will be apparent that the printer code effects a considerable saving in line time as compared with the Morse code. For one thing, the spaces between letters may be entirely eliminated, there being no need to provide the printer with the short rest which the ear requires. The average length of each character is also somewhat reduced.

The printer code is technically known as a two-element, five-unit code, because it employes two current values (one positive and one

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* *It will be convenient to refer to the shortest marking unit as a dot, and the maximum rate at which dots can be satisfactorily received as the limiting dotting speed.*

negative) and each character is five dot lengths in duration. By employing three current values it becomes possible to shorten still further the duration of each character. The relationship which exists is so readily deduced that it may interest the reader to follow the argument.

Imagine a succession of time units, each of which is to be assigned one of the possible current values. For the two element code, each unit can have either of two current values. Hence in a series of five units, the possible number of distinct characters is 2 x 2 x 2 x 2 x 2 = thirty-two. For the three element code, the expression becomes 3 x 3 x 3 x 3, etc., and now it is necessary only to give each character a length of four units in order to secure eighty-one different characters. In fact, with a length of but three units, there will be twenty-seven distinct characters. So far as diversity is concerned, the three-element three-unit code is therefore practically equivalent to the two-element five-unit code. Since the time intervals are in the ratio 3:5, one would naturally conclude, were there no other factors to consider, that the three-element code is decidedly superior. As a matter of fact, the reverse is the case, this rather unexpected upset being due to the contribution of the vibrating relay which can be used only with a two-element code.

A simple explanation will make clear the functioning of the vibrating relay. Consider a single dot. It is formed by a sudden reversal of the battery potential which is applied to the line, and at the end of a short time interval an equally sudden return to the original potential. In response to these potential changes, a sharp current pulse is formed at the sending end, as shown in Fig. 1. Due to the charactertistics of the line, however, this pulse is no longer sharp upon its arrival at the distant end. It partakes of the shape indicated in Figure 2 which shows that the received current rises sluggishly instead of instantaneously. The time required

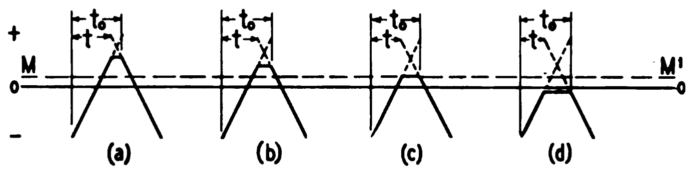


Figure 3

for this sluggish rise of current is called t_o.

In Figure 3 there have been made a number of constructions showing the effect of making shorter and shorter dots. Let the height of the line MM[1] represent the marginal current value of the receiving relay. At (a) is shown a current pulse corresponding to a dot in which the length of the dot *t* is just less than the time of rise of the current, t_o. It well exceeds the current margin of the relay and therefore causes the receiving apparatus to respond. The same is still true in the case of the shorter dot shown at (b) while at (c) the receiving relay is merely on the point of responding; at (d) it will not respond at all so that the marking unit will fail and the spacing unit will continue.

We see then that with a code using only two current values and with line and terminal apparatus such as to yield the received currents shown in Figures 2 and 3, and with

a receiving relay which operates with a negligibly small current, no code character shorter than half the time interval t_0 can be recorded. Hence, as the dotting speed is increased, the dots or shortest characters are the first to fail. Could we design the receiving apparatus so that a local source of energy would make the dots at the rate at which they are sent and then utilize the transmitted energy of each long unit merely to lock the receiving mechanism during the period necessary to form such longer units, the dotting speed of any given line could be increased. This is just what is accomplished by the vibrating relay. It usually takes the form of a mechanical oscillator, its capacity and resistance being so adjusted that its natural period of oscillation is the same as the dotting speed.

This device automatically provides for reception of the shortest units—in fact, so long as no signal is received over the line, it will mark off a continuous succession of dots—and failure to receive longer units will occur only when the received current for these longer units is not large enough to dominate the local dot-forming current. By means of this device, a dotting speed well above that indicated by half the interval t_0 can be employed.

Referring to the frequency characteristic of a telegraph line, its dotting speed is susceptible of a simple statement in terms of the upper cut-off frequency. If this cut-off is raised, the slope of the arrival curve is increased, that is, the received current builds up at a greater rate. Consequently, the higher the cut-off frequency of the line, the higher is its dotting speed. So long as the rate at which we send dots over the line does not exceed its cut-off frequency, communication can theoretically be carried on satisfactorily. In practice, because of interference and other variable factors, the dotting speed is held down to about one-half of the cut-off frequency. Since the dotting speed is seldom greater than 30 per second the cut-off frequency of a telegraph line may be placed at about 60 cycles. Thus the band of frequencies required in telegraphy is quite narrow compared to the band extending from about 200 to 2500 cycles necessary for satisfactory voice communication. Under certain conditions, use of the vibrating relay enables the practical dotting speed to be made equal to the cut-off frequency and thus the dotting speed may approach double the speed possible without the relay.

It may be of interest to point out that on account of the narrow frequency band required to transmit the telegraph code characters, the message capacity of an ordinary telephone line is much greater when used as a multiplex telegraph channel than it is when used for communication by telephone. For the latter it has a capacity of about 120 words per minute. Operated as a multiplex telegraph system without intermediate repeaters it can transmit as many as 2000 words per minute.

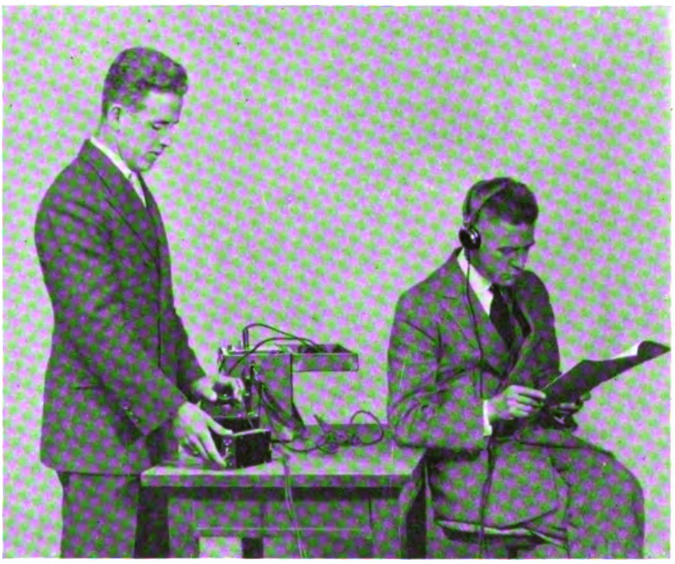
Psychology Aids in Tests of Hearing

By W. L. BETTS
Apparatus Development Department

BY the use of methods developed in these Laboratories, it is possible to make very accurate measurements of the sensitivity of the ear. The degree of accuracy is limited, not by our skill in measuring small currents, but by the ability of the listener to be sure whether he hears the test tone or not. As an aid in this direction, Western Electric audiometers have always been provided with a push-button to interrupt the tone. Should a patient's hearing seem entirely too acute, the tester cuts off the tone; the report "I still hear it" then means only one thing — that the patient has been flattering himself, to the extent of several TU.

As a further aid to tests of hearing with the audiometer, a circuit has been worked out by which the tone can be switched to either ear or to both. This device, known as the No. 42-A Test Set, brings to use several principles of psychology. For instance, does a loud tone sound in the left ear, the left eye blinks ever so slightly, although the patient may claim that all is silent as Sahara.

Conduction of sound by the bones of the skull also offers means to investigation of asserted deafness. At a more or less definite volume, sound impressed on one ear will be conducted to the other so that were a person totally deaf in one ear he could hear by bone conduction to the other when a tone of sufficient loudness was applied to the deaf ear. Not aware of this fact, a subject claiming total deafness in one ear might deny hearing anything, although the tone was loud enough to be heard by the other ear. In fact, if he wished to deceive the examiner he would be unable to do so even if he were aware of bone conduction, because he would not



How the 42-A Test Set and the 3-A Audiometer are used to detect deafness is demonstrated by J. A. Battle and W. L. Betts

know the actual loudness level at which conduction occurs and so would not know when to signal.

Another effective test to avoid misrepresentation by the subject is to have the subject read aloud from a book in his natural voice while a tone is switched from ear to ear. Use is then made of two facts of psychology —that the sound of one's voice is necessary for the regulation of his voice intensity, and that one's own voice can be "drowned out" by a loud tone. A person of normal hearing in both ears will not change the volume of his voice as the tone is switched back and forth because, at all times, he has one ear with which he can hear himself talk. He will raise his voice and almost shout, however, when the tone is switched on both ears at the same time, as then his own voice is drowned out. Were the subject actually deaf in one ear he would raise his voice every time the tone was put on the one ear in which he could hear.

A similar test may also be used for a person claiming deafness in both ears. When the tone is switched on and off both ears, the voice intensity will vary with the tone if the reader is actually able to hear. If he is not. switching the sound on and off will have no effect on his reading.

Where deafness is claimed in one ear, the suggested procedure is to switch the tone at different intensities rapidly back and forth from one ear to the other. The subject of the test is supposed to signal every time he hears a sound and because of the rapid changing from ear to ear with the accompanying variation in volume a false claim soon becomes apparent. This is because to signal truthfully each time a sound is heard is an almost instantaneous act but much more time is required if one has to stop to decide in which ear the sound occurred and then to remember whether that is the ear for which he has claimed deafness. If the tones are applied at fairly rapid intervals the mind can not act quickly enough when an additional thought train is required to give the correct response.

New Languages from Old

By CLYDE R. KEITH
Research Department

MAKING a new language to order is now possible through recent work of the Research Department. To accomplish it, normal speech is "inverted," so that for every vibration a new one is produced whose frequency is equal to some selected constant frequency minus the original frequency. By the use of this inverting apparatus words spoken in English before a microphone may be reproduced on a loud speaker as a succession of totally different sounds, apparently having no relation to the original speech. These new sounds may, if desired, be translated back into English by passing them through a similar group of inverting apparatus. The fundamental processes involved in making inverted speech are not new, and it is not proposed to use such speech in competition with Esperanto, but the method illustrates in a very striking way the process of modulation and frequency conversion which is so essential to radio and carrier communication.

In forming inverted speech the modulating or inverting frequency acts somewhat as a lens does in inverting the image of an object: causing the top to appear at the lower part of the field and the bottom at the upper. The inversion might be effected about any convenient frequency but in order to have the resulting sounds at the pitch level of ordinary speech it is necessary to select a frequency only slightly above the normal speech range. The apparatus now developed uses three thousand cycles as the inverting point. Although there are frequency components in ordinary speech above this value they are eliminated by filters before the speech passes to the inverting apparatus, but this does not objectionably affect the quality of the speech.

With a normal speech range of from 100 to 2900 cycles and an inverting frequency of 3000, the resulting, or "inverted," speech also occupies the band from 100 to 2900 cycles but in a reverse order. A pure tone of the pitch of middle "C" on the piano scale which has a frequency of 256 cycles per second would become 2744 cycles or 3000 minus 256. Consequently the voice of a person talking in a low tone comes out of the "inverted" speech apparatus as a high pitched squeak, with a low grunt now and then due to the overtones in the original speech wave.

On listening to inverted speech for the first time nothing is understood. It is as unintelligible as the strangest foreign language. However, one may learn to interpret it by listening to words first spoken normally and then translated by the speech inversion equipment. "Illinois Telephone Association," for instance, when inverted sounds "Oyaneon Playafiend Acecilofin." To a considerable extent, therefore, a person could learn this inverted language; but as there

are some sounds in it which the average person would have difficulty in imitating, a vocabulary would have to be made up which did not contain them.

The process is readily reversible. The "inverted" speech may be imitated before a microphone connected to the inverting apparatus which will translate it back again to English. The intelligibility of the reproduced or re-inverted speech depends only on the fidelity with which the inverted speech is imitated. In the inverting process there is practically no loss of quality so that phonograph records may be made of the inverted speech from which the sound may be picked up by an electric reproducer and re-inverted to normal English.

Records of inverted speech were first made about a year ago by J. W. Horton to illustrate the nature and use of side bands in carrier communication. Complete equipment had been arranged for a demonstration which was given in connection with a lecture by S. P. Grace at a convention of the United States Independent Telephone Association in Chicago last October. Several phonograph records were made from inverted speech produced by special laboratory apparatus which insured the best quality on the record. The records were played first to show how little resemblance the sound bore to ordinary speech. Then some of the inverted speech coming from the phonograph was picked up with a telephone transmitter and reinverted by the portable speech-inversion set. In this way the reinverted speech, or ordinary English, would come from a loud speaker at the other side of the stage. At the same time the unintelligible output of the phonograph continued and could be heard but only faintly, since it was largely masked by the readily-understood re-inverted speech from the loud speaker. To show that the reinverted speech actually came from the unintelligible sounds given off by the record, the telephone transmitter was moved away from the phonograph and as a result the translated speech stopped.

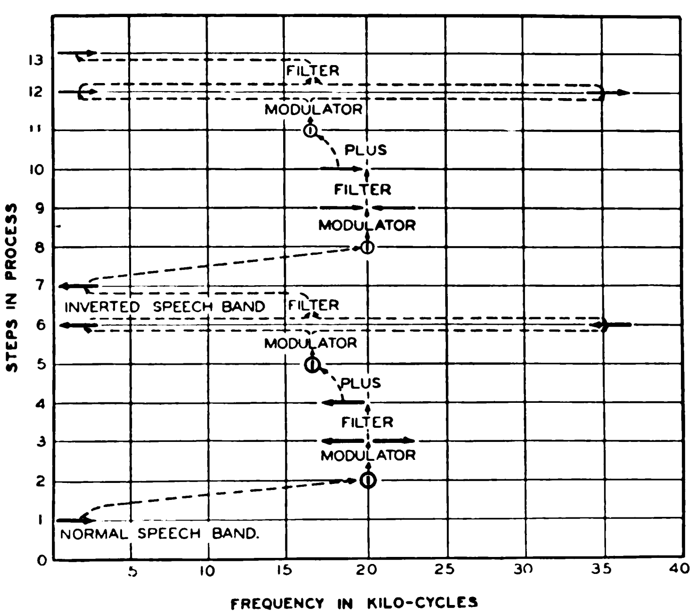
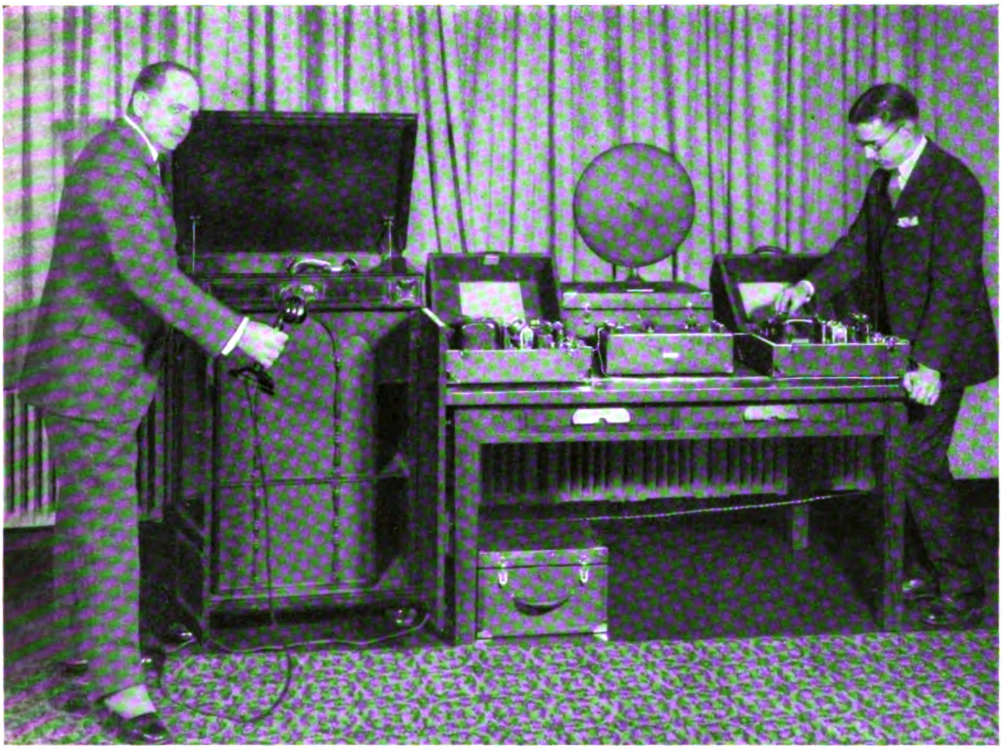


Figure I

In the actual apparatus two modulating steps are used, one at twenty and the other at seventeen kilocycles, which give the same overall result that would be obtained from a single modulation at three kilocycles. In the process of modulating, certain distorting frequency components are



S. P. Grace and L. W. Davee illustrate the method of using a stage set-up of speech-inversion apparatus

unavoidably introduced which are difficult to filter out when the modulating and modulated frequencies are too nearly alike, as would be the case when a voice band of from one to twenty-nine hundred cycles modulate a three thousand cycle frequency. By allowing the voice band to modulate first a twenty kilocycle frequency the distorting frequencies are eliminated.

The inverting process may be readily followed by reference to Figure 1 which shows all the steps from the original band of voice frequencies to the inverted band and then back to the normal order. Following up the diagram step-by-step, the initial band modulates a twenty-kilocycle frequency resulting in an upper and lower side band. The upper is filtered out and the lower is then modulated by a seventeen kilocycle frequency. This again gives two side bands of which the upper is filtered leaving the lower which is in the same range as the original voice band, from one to twenty-nine hundred cycles, but in the reverse order, one hundred cycles in the original band becoming twenty-nine hundred in the inverted band and the original twenty-nine hundred cycles becoming one hundred. The steps in reinverting the inverted band to normal speech may be followed by continuing up the diagram.

In the development of the apparatus and in the making of the records used by Mr. Grace, A. G. Landeen and A. C. Keller cooperated with the

author. The speech was delivered before the microphone by L. Howell Davis of the Victor Talking Machine Company, who has an exceptionally good recording voice. While at present the system for reinverting speech is used only for demonstrations, it is possible that by-products arising from a knowledge of its capabilities may prove of considerable value.

Transatlantic Telephony

"The American Telephone and Telegraph Company has officially disposed of recent rumors that transatlantic radio telephone communications are not being employed as much as might have been expected. At the close of the first year's operation the service is finding a steady and increasing use and probably will be extended. . . . The daily period of service has been extended from four and a half hours to ten and a half hours, during which excellent transmissions are obtained. . . . Improved service is bound to mean increased capacity and diminished cost. The first year's experiment may safely be taken as a prophecy that telephoning between the United States and Europe will soon become as commonplace as telephoning now is between New York and every other important American city."

Editorial, New York Sun, January 20, 1928.

From January 7, *the first day of service, to December* 20 *there were* 2173 *calls, of which about nine-tenths were completed.* 1159 *of the calls originated in America, and* 1014 *in Britain. By November the traffic for an average business day was seven and three-fourths completed calls lasting five minutes each, and each representing a cost of* $125. *By means of the transatlantic telephone service, this month there will be a joint meeting of the American Institute of Electrical Engineers, holding its Mid-Winter Convention in New York, and the Institution of Electrical Engineers, meeting in London.*

"What Are The Chances That..."

By THORNTON C. FRY
Research Department

EVERYBODY asks this question; but not everybody understands how to answer it. In fact the attempt to find answers to questions of this sort has led to an entire branch of mathematics — the Theory of Probability. Of its many aspects, this short article considers only one: the reasons for expressing measurements of probability in the form in which they are ordinarily given.

In the first place, as every one knows, to measure anything there must first be a unit of measure. Also, although one thinks of this particular fact a little less often, there must be an agreement upon a method of dividing the chosen unit before one can measure magnitudes not exactly a unit in amount. In measuring length, for example, (and the same is true of any other quantity) we must have a unit and we must agree upon a method of subdividing this unit. From a standpoint of common sense, it seems reasonable to have a scale of such a nature that when two like objects are placed end to end we shall find their combined length to be represented by just twice as great a number as the length of either one alone. Such a scale we call a "uniform scale."

The same ideas apply when we come to set up a scheme for measuring probability. Rather illogically, perhaps, we shall take up these two points in their inverse order, first discussing what we mean by a uniform scale of probability and then defining our unit of measure. An illustration will help in developing our ideas.

Imagine two men talking about Peary's trip to the North Pole, and one of them asking: "What is the chance that he got there on Sunday?" Obviously there is no point in asking this question if they know the answer, so we shall assume that they, like ourselves, are ignorant of the actual recorded day.

To this question we can not give a definite answer until we have defined our method of measuring probability, so we must do what we always do with unknown numbers: represent the desired answer by a letter, p. Next, we remember that, since we are in complete ignorance as to when Peary arrived at the North Pole, the chance of his having reached there on Monday, or Tuesday, or any other day of the week, is the same as the chance of his having reached there on Sunday. All of these then are equally likely. In other words, we have seven *equally likely* possibilities.

If we had seven *equally long* objects, the length of each being l, we could begin to construct a uniform scale of length by putting two of them end-to-end and calling the resultant length $2l$; then adding on a

third and calling the new length, $3l$; and so on. We ought, therefore, by making the proper use of our equally likely things, to be able to construct a uniform scale of probability. The only difficulty appears to be that of finding a suitable analogue for "end-to-end", and this difficulty can be resolved by a very simple observation.

If we ask, "What is the chance that he arrived on either Sunday or Monday," it seems just as natural to represent the answer by $2p$ as it does to represent the combined length of two of our like objects by $2l$. This relationship of "either-or" therefore occupies the same place in our thought processes regarding probability that "end-to-end" does in geometry. It is not *necessary* that we should represent the probability of his having arrived on either Sunday or Monday by the number $2p$, but it impresses us as a very *sensible* thing to do. Similarly, we say the chance of his having arrived on either Sunday, Monday, or Tuesday should be $3p$; the chance of his having arrived between Sunday and Wednesday $4p$, and so on. Finally, after we have put all of our equally likely things "end-to-end" in this way, we arrive at the conclusion that the chance of his having arrived on some one or other of the seven days of the week is $7p$. Beyond this point we cannot go — and herein lies one very fundamental difference between measuring probability and measuring length — for some one of these things *must* have happened. There are no further possibilities, and so $7p$ must be that number which represents certainty.

That is how we set up our uniform scale of probability. Now how shall we choose our unit of measure? As there is little to guide us in this matter, our choice must be more or less arbitrary, as it is in the choice of a unit of length. It has always seemed to me that the most suitable choice would be one which caused certainty to be represented by ∞, that is "infinity," for certainty is the biggest possible probability in the same sense that ∞ is the biggest possible number. Yet, curiously enough, this is about the only symbol which we cannot use for certainty. For suppose we do: then we arrive at the conclusion in our Peary illustration, that $7p = \infty$. Then p must be one-seventh of infinity and since infinity is by definition a magnitude so great that its parts are also infinite, we come to the statement that $p = \infty$ too. Thus we become involved in the absurdity that the chance of his having arrived on Sunday is represented by the same symbol as certainty, though obviously we are not at all certain that he did. We must therefore admit—and for my part the admission is always made with a feeling of regret—that this choice will not do.

Among other numbers which might possibily represent certainty there is no one which has any greater claim than the number 1 itself. Therefore it has come about, that a thing is said to have a probability $1/n$ when we are sure that either it, or one of n-1 other equally likely things, is bound to happen. In our particular illustration we put $7p$ equal to 1, and conclude that the chance p of Peary having reached the North Pole on Sunday is just one-seventh.

This, then, is the exact answer to the question, "What are the chances that——" *It is a number read from a uniform scale of probability in which the unit of measure is certainty.*

The usual definition reads: "If of n possible cases, m are favorable to the occurrence of an event, and if all cases are equally likely, the probability that the event will occurr is m/n.

As the "cases" spoken of in this definition are equally likely, the probability of any one may be represented by p. As only n are "possible"—which means that some one of them is sure to occur—we know that $np = 1$. Hence $p = 1/n$. Finally, if we consider the m "favorable" cases, their combined probability must be m/n; and as "favorable" merely means that our event always accompanies these "cases", and never happens otherwise, it follows that the probability which we seek is really m/n.

So the two definitions are equivalent after all, and we will get to the same result in the end whichever one we use. For myself, however, I like best the one to which this article has led us, for it seems to me to give us a somewhat clearer insight into what we really do when we answer the question, "What are the chances that——"

Direct Telephone Circuits

A direct circuit from New York to Tampa, Florida, 1225 *miles long, was opened December* 17. *This is in accordance with the policy of eliminating the need for switching wherever traffic justifies direct circuits. The number of such circuits between far distant cities is much greater than is supposed. Between Los Angeles and New York there are two direct circuits, each* 3412 *miles long, the longest direct circuits in the world. Between Los Angeles and Chicago there are four, each about* 2600 *miles in length. Of the longer direct circuits from New York, one runs to Dallas,* 1900 *miles; two to Havana, about* 1700 *miles each; four to Miami, about* 1400 *miles; and three to New Orleans,* 1450 *miles. The greatest wire mileage in a single group is between New York and Chicago, where there are thirty-three direct circuits whose total length is* 29,882 *circuit miles.*

Tooling-Up the Drafting Room

By W. L. HEARD

DRAFTING has been an outpost of conservatism in the adoption of modern mechanical methods. There are good reasons for this because drafting is a difficult field for short cuts. The tracing cloth on which drawings are made is not friendly to stamps or stamping methods. Special inks must be used for the sake of durability and their slow drying is discouraging to speed. However, a very effective tool for simplifying the lettering of drawings was developed a few years ago and quickly adopted by the systems and other drafting rooms in the Laboratories.

The Wrico lettering guide, as it is called, is a plate of transparent material, punched full of apparently meaningless and odd shaped holes. These holes are along a narrow strip down the center of the plate, which has parallel edges so it may be placed against the "T" square. This central strip is thinner than the rest of the plate so that its under surface will clear the tracing cloth by a small distance and thus not smear the ink when it is moved along the board. Seemingly made at hazard, these holes are actually very carefully shaped so that they may serve as guides for a special pen with which lettering may be quickly and neatly done. As an example of the method, Figure 1 shows the two successive steps by which the letter "B" is made. After the first part of the letter has been formed the guide is moved along to the hole that is used to make the second part.

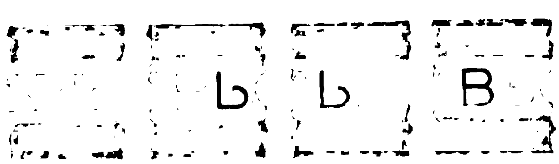


Figure 1—Method of making letter B with a standard Wrico guide

All drawings have titles and generally other lettering so that a simplified lettering system was naturally the first short-cut method to be produced. In drawings of telephone systems, however, relays in their many forms rank second only to letters in the number used. As they are much more complicated than letters, however, they require correspondingly more time to make and offer greater inducements for the use of labor saving devices. The effort was made, therefore, to adopt the principle of the Wrico guide to the making of relay symbols. After a little experimenting the guide shown as Figure 2, now known as the Wrico

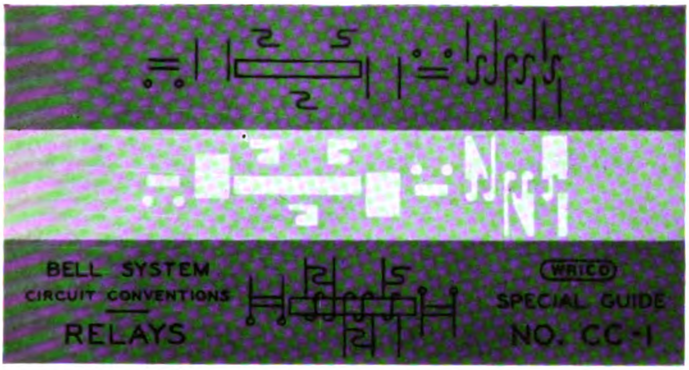


Figure 2—Wrico special guide CC-1

the great saving in time made by the use of this tool is evident. In addition there is a noticeable improvement in uniformity. Each type of relay is always made exactly the same no matter which draftsman may be doing the work.

These more mechanical methods are a convenience to all grades of draftsmen but they are peculiarly valuable to beginners for they permit them to become productive early in their training and at the same time they free the more expert for work on which their craftsmanship will find a wider field of usefulness.

Special Guide No. CC-1, was devised.

Dozens of different types of relays are indicated on systems drawings, of which a few are shown as Figure 3. Any one of these may be quickly, easily, and uniformly made by the use of this special guide. To one at all familiar with drafting methods

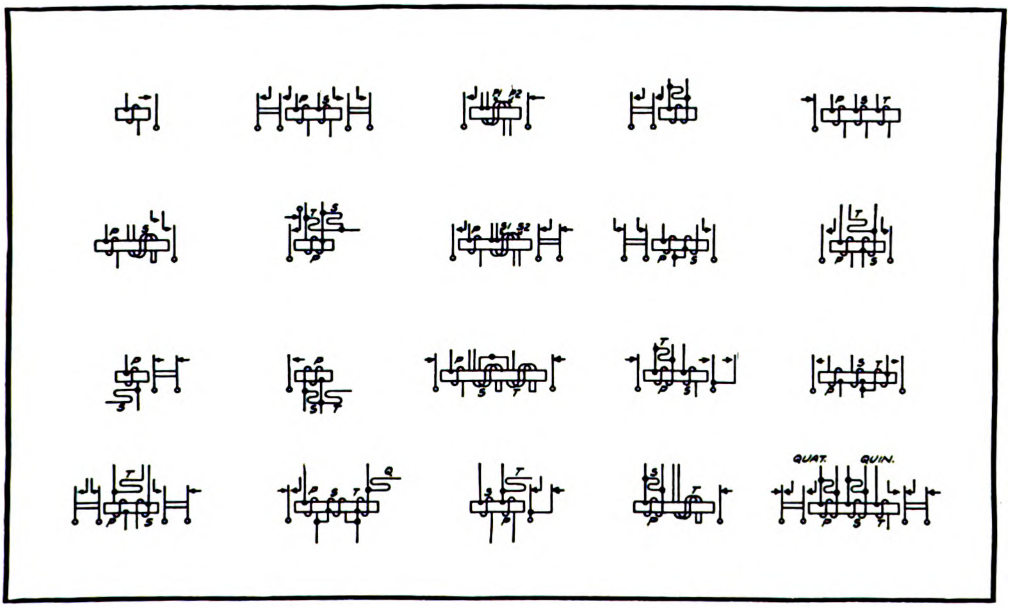


Figure 3—Typical relay symbols used on systems drawings



WILLIAM F. HOSFORD

Director, Bell Telephone Laboratories

Recently elected a Director of the Western Electric Company and its Vice-President in charge of Manufacture, Mr. Hosford was elected a Director of the Laboratories to succeed Charles G. Du Bois

News Notes

MR. JEWETT spoke at the Alumni Dinner of Massachusetts Institute of Technology held January 7 in Boston, on "Scientific Education — Do We Know What We Want and Can We Get It?"

MR. JEWETT attended the hearing of the Federal Radio Commission in Washington on January 17 and 18.

MR. CRAFT has been visiting a number of cities on the Pacific Coast. He spoke on Coordination of Researches to sections of the A. I. E. E. at Seattle, Portland, San Francisco and Los Angeles, and to the Electrical Development League at San Francisco.

J. W. HORTON spoke to the Colloquium January 9 on Frequency Measurements, and E. U. Condon January 16 on Recent Developments in Quantum Theory.

A FEATURE of the recent annual convention of the I. R. E. held in New York on January 9, 10, and 11 was an inspection trip to 3XN, our radio experimental station at Whippany, New Jersey, at which there were about four hundred members of the Institute. Following a buffet luncheon, the group inspected the new fifty-kilowatt broadcasting transmitter and also a set for measuring radio field strength, recently developed for commercial sale.

DURING 1927, the American Telephone and Telegraph Company conducted a comprehensive study of commercial aviation in its present ecnomic, commercial, and technical aspects with the conclusion that it could serve the industry by a further development of equipment and methods for communication along airways and to airships. Readily available means of communication, both wire and radio, should help to minimize the hazards of weather, of losing the course along the airway, and of collision. The problem is at first one of research and development, and the Bell Telephone Laboratories have, therefore, included in their 1928 program a substantial amount to be devoted to the advancement of safety in aviation by the application of electrical communications.

RESEARCH

C. J. DAVISSON, L. H. Germer, K. K. Darrow and E. U. Condon were members of a party of eighty-five physicists entertained January 7 at the private research laboratory of Alfred L. Loomis at Tuxedo Park. The occasion was a conference on atomic physics held in honor of Professor J. Franck of Göttingen.

D. A. MACINNES of the Rockefeller Institute visited the Laboratories January 19, and spoke informally to members of the Chemical Group.

W. E. CLEMENCY visited the Kimble Glass Company at Vineland, New Jersey, to select glass tubing for use in machines for filling transmitter buttons.

R. M. BURNS attended a meeting on corrosion held in Chicago December 6 to 8 under the auspices of the American Petroleum Institute. He

also visited the Forest Products Laboratory at Madison, Wisconsin, for a discussion of wood acidity, which was continued when Dr. L. F. Hawley of that organization visited West Street.

C. A. FINLEY was at Hawthorne for about two weeks beginning January 5, instructing personnel there in methods of adjusting and testing the 1-A apparatus test set.

F. F. FARNSWORTH and C. D. Hocker attended a sub-committee meeting of the American Society for Testing Materials in Philadelphia on January 9. The meeting dealt with preparation of specifications for galvanized wire and stranded wire.

H. A. FREDERICK, D. G. Blattner, H. C. Harrison and A. C. Keller attended the monthly conference with the Victor Talking Machine Company on December 12 at Camden, New Jersey.

H. A. HENNING visited the Victor plant at Camden January 9 and 10 to investigate the extent of the special experimental records available.

J. W. HORTON spoke on "Television" to the Boston Section of the A. I. E. E. on January 11.

G. W. ELMEN has been recommended for the Elliott Cresson Gold Medal by the Franklin Institute Committee on Science and the Arts. The recommendation is "in consideration of his extended researches in the magnetic charactertistics of nickel-iron alloys resulting in the invention of permalloy."

H. E. IVES spoke on Television to a regional meeting of the A. I. E. E. at Norfolk, Virginia, on December 20. At the same meeting H. P. Charlesworth, Plant Engineer of the American Telephone and Telegraph Company, spoke on Transatlantic Telephony, C. A. Robinson, Chief Engineer of the Chesapeake and Potomac Telephone Company, spoke on Picture Transmission, and C. O. Bickelhaupt, Vice-President of the Southern Bell Company, spoke on the Progress of Communication. From Norfolk Mr. Ives went to Atlanta, Georgia, where he spoke on Television on January 23.

INSPECTION ENGINEERING

H. W. NEWLUND, who has been assisting R. C. Kamphausen in the St. Louis field territory, has been appointed Local Field Engineer at St. Louis. Mr. Kamphausen has returned to New York for a special assignment in field engineering work.

D. S. BENDER has been appointed Local Field Engineer in the territory of the Southern New England Telephone Company, with headquarters in New York. Mr. Bender takes the place of R. J. Nossaman, who will now give all his time to directing the Field Engineering forces.

J. A. ST. CLAIR, Local Field Engineer at Atlanta, recently visited Jacksonville, Miami, West Palm Beach and other Florida points in connection with regular work in his territory.

J. M. SCHAEFER, Local Field Engineer at Omaha, visited Denver, Minneapolis, and Enderlin, North Dakota, recently.

S. H. ANDERSON, and J. R. Stone of the Systems Development Department, visited several central offices in Philadelphia on December 20 with engineers of the American Telephone and Telegraph Company and of the Western Electric Company, to study the commutation on Type M generators.

Outside Plant Development

C. D. Hocker attended a meeting of the American Society for Testing Materials in Philadelphia on January 9. On January 10 and 11 Mr. Hocker and F. D. Powers visited the Bureau of Standards and the Department of Agriculture in Washington, in the interest of studies of the characteristics of rope, friction tape, rubber tape and leather.

C. S. Gordon, with engineers of the American Telephone and Telegraph Company, was in New Haven January 6, in connection with studies of drop wire attachments.

E. M. Honan attended a sectional meeting of the Rubber Committee of the American Society for Testing Materials, held in Buffalo on December 1 and 2.

S. C. Miller visited manufacturing plants in Lebanon and Pittsburgh during the early part of January in connection with development work on outside plant hardware.

Patent

During the latter part of December and the earlier part of January W. G. Crawford, G. T. Morris, J. C. R. Palmer and J. W. Schmied were in Washington for the prosecution of applications for patents. During the same period J. A. Hall visited Chicago in connection with patent matters.

Laboratories motorists will be interested in learning that W. C. Kiesel has been appointed Recorder of the Borough of Florham Park, New Jersey. The office is colloquially known as Justice of the Peace.

Systems Development

O. H. Kopp, W. Whitney and L. F. Porter visited during the past month the new Main office at Cleveland, which was placed in service early in December.

W. L. Dodge, E. W. Hancock and G. A. Hurst spent several days in Boston, investigating a trial installation of new message registers.

A. F. Burns made studies of protection by high speed interrupters at Syracuse and Utica.

F. B. Anderson and T. A. Marshall observed trials of new testing methods for high insulation at Harrisburg. Shippensburg, Ligonier and Pittsburgh, on the New York-Chicago cable. In preparation for the trial, B. W. Kendall visited the Training School for the testboard men who were to carry on the test. He talked to the school, and inspected the new measuring apparatus.

H. T. Langabeer visited Buffalo to test a new model gas-engine generator set.

A. D. Knowlton visited Hawthorne for manufacturing information regarding proposed new developments of P. B. X. switchboards.

R. D. DeKay visited West Lynn, Massachusetts, and J. R. Stone, Fort Wayne, Indiana, for discussions with engineers of the General Electric Company.

C. E. Boman and R. E. Noble visited the new step-by-step and toll installation at Utica.

F. T. Forster discussed storage battery equipment with the Electric Storage Battery Company at Philadelphia.

W. L. Ross visited the Westinghouse Electric and Manufacturing Company at Pittsburgh to discuss a rectifier for use with P. B. X. boards. Then he went with L. Earl to Mercer, Pennsylvania, to conduct noise tests on an automatic power plant.



Otto Muller and his birthday cake

J. R. KIDD is representing the trial installation group at Chicago, looking after the first installation of a semi-automatic P. B. X. using line finders.

To observe the thirty-fifth anniversary of his joining the Bell System, friends of Otto Muller presented him with a cake and held a short celebration in his honor, in the Model Shop. Behind Mr. Muller and the cake is a large model which he made recently, showing a receiver and transmitter in cross section.

GENERAL STAFF

S. P. GRACE spoke on January 17 before the A. I. E. E. Section at Erie, Pennsylvania, on recent developments of the Laboratories, particularly speech inversion.

DURING January, John Mills visited several universities in the South describing to students of science the work and organization of the Laboratories and particularly discussing the problems of a graduate in starting as an engineer. He visited Duke University, University of North Carolina, North Carolina State College, and in company with Kendall Weisiger of the Southern Bell Telephone and Telegraph Company he also visited Emory University, Georgia School of Technology, and the Alabama Polytechnic Institute. At the latter institution he spoke over the radio on "How Your Radio Works."

UNDER the auspices of the New England Telephone and Telegraph Company, on January 18, P. B. Findley addressed the Boston post of the American Signal Corps Association on some of the fundamental principles of electrical communication.

The Twenty-Four Inch Cone

By G. R. LUM
Apparatus Development Department

HAVING passed the Apparatus Development Department's examinations, the new Five-Sixty Type Loud Speaking Telephone is ready to make its bow to the public and take its place in the telephone and radio world. Manufacture of its predecessor, the Five-Forty Type, will be discontinued as the newer one becomes available for sale.

With a twenty-four inch cone instead of the eighteen inch of the older type, the new speaker will reproduce the lower frequency tones somewhat more perfectly than is possible with a lesser diameter. In addition to this major improvement the driving rod has been shortened which makes it stiffer and the driving action more positive.

The soft brown color of the five-forty has been retained for the new cone but the relatively large blank surface has been relieved by a wider border which harmonizes with an eight cusped design at the center. On the whole the pattern is more graceful and pleasing than the severe and somewhat scantier design of the five-forty.

Like the older cone, the five-sixty is made with three types of terminals, the pin tips, the telephone plug, and the two-prong Hubbell plug. The power requirements are the same and in all respects the newer model may



The twenty-four inch cone

be used in place of the older one. The thirty-six inch cone described in the Record for December two years ago still proves to be a leader and the five-sixty will readily take its place as a brilliant younger brother.

Club Notes

Handball

THE Club Handball tournament will be held on Tuesday and Thursday evenings, during March, at Labor Temple, under the same rules used for the last tournament. All matches will be decided by one game except the semi-finals and finals, where the victors must win two out of three games. There are to be four prizes, and in addition the team for outside competition will be chosen on the basis of showing in the tournament. Entries should be sent to D. D. Haggerty by February 25, with a fee of twenty-five cents.

Basketball

A most exciting and interesting basketball game was staged at Stuyvesant High School on Wednesday evening, December 14, between teams representing the Laboratories and the Hudson Street forces of Western Electric. Assisted by five hundred rooters from West Street, our team defeated Hudson Street by a score of 27 to 22, and thereby won undisputed title to the metropolitan championship of the Bell System. Our team started the second half with 11 points against 16 for Hudson Street, and within forty-five seconds tied the score. From then to the end it was a battle which those present cannot soon forget. Both teams played top-notch basketball throughout. O'Neil, Maurer, Gittenberger and Steinmetz starred throughout the season and finished among the first twenty in points scored.

Due to the exceptional interest shown by both players and spectators the Bell Systems League is here to stay. Plans have been made for the 1928 season, and four other branches of the System have been invited to take part in the activities of the league.

The first half of the departmental league's season ended with the Equipment team on top and undefeated. The second half began on January 17 and will end the latter part of this month. The Equipment team, which now holds the championship trophy, will play the team leading in the second half of the season for possession of the championship trophy for the coming year.



There will be no scheduled hikes this month, but those wishing to plan trips of their own can get information and assistance from Phyllis Barton, who has maps and a great store of facts about the surrounding country.

Music

The Club Quartette was the guest of Western Electric Post of the American Legion at its December 20

meeting, and rendered several selections during the dinner period and also during the open meeting which followed.

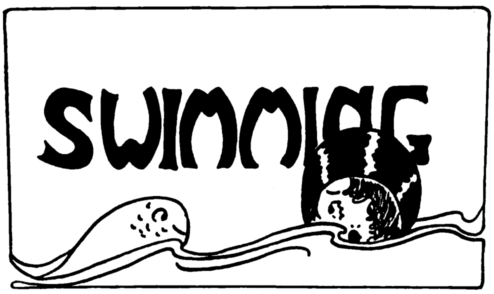
Bridge

The first half of the men's bridge tournament came to a close Monday evening, January 9, with T. V. Borland in first place and C. A. Smith and H. M. Hagland second and third respectively. The race was close from the first, and it was not until the last hand had been played on the last night that the winner was known. The second half of the season, consisting of ten nights of play, started January 23.

WOMEN'S ACTIVITIES

Golf

The women interested in golf will be glad to know that they can take lessons at the Vander-Built-In Golf Course on Forty-Second Street. Tickets are a dollar and a half per lesson, and can be secured through Marie Boman or Vivian Kilpatrick.



Another season of fun and instruction has started at the Carroll Club under Miss Stiehl's direction. Each Monday at seven and each Wednesday at five-thirty the women gather for a half hour. For a time it was doubtful whether a class could be scheduled at the Monday night period, but those who were a bit blue over the prospect are now correspondingly glad that it is going ahead. One of last season's swimmers said that never before had she learned so much in such a short time.

Bridge

Don't forget that Tuesday is bridge night, with play starting in the Rest Room at five fifteen. The Mid-Winter Tournament is just getting into swing, and Katherine Munn would like to have all her players lined up as soon as possible.

Basketball

The outside schedule of the Women's Basketball team is about half completed, with gratifying results so far. The members enthusiastically striving to keep up the record are Natalie Skinner, Lillian Kaempffe, Mandy Reinbold, Jean Hassett, Marie Boman, Margaret Brisbane, Alice Pease, Marion Grimm, Ann Barioni, Harriet Newman and Mary Zworick, and several others who come out for practice and are ready to substitute if needed. The remaining games definitely scheduled are a return game with the Vacuum Oil Company at Labor Temple on February 9, a return game with the Seaboard National Bank at the Bowling Green Association February 16, and the game all are especially awaiting, with the People's Palace in Jersey City on Tuesday, February 21, at six o'clock. To complete the season there will be a few more games booked.

Life Insurance by Payroll Deduction

Life insurance may now be carried by members of the Laboratories by means of monthly deductions from salary. This is a natural complement to the stock purchase and savings plans. Policies taken out under this arrangement will be written by the Equitable Life Assurance Society, the company chosen after a thorough investigation.

All of the Equitable's standard forms of policies are available and the regular quarterly rates will be charged although payments occur monthly. In addition to the convenient payments, the plan provides that no medical examination will be required except for policies over $10,000 *and except in instances where the health declaration makes it desirable.*

All negotiations except payment of premiums will be carried on by the individual directly with the Insurance Company. Mr. L. M. Bunting, an expert on all phases of life insurance, now occupies Room 144 *and members of the Laboratories should consider that he is available for consultation regarding their insurance problems. This consultation is entirely confidential and implies no obligation. Bearing in mind that probably as much as four-fifths of all the money men leave to their families is in the form of life insurance, the importance is obvious of obtaining the best possible advice and assistance.*

BELL LABORATORIES RECORD

A NEW
LOUD SPEAKER
By A. L. Thuras

STEP-BY-STEP
CORDLESS "B" BOARD
By W. J. Lacerte

WATER COOLING FOR
RADIO
By J. O. Gargan

MARCH 1928 VOL. 6 NO. 1

Bell Laboratories
Record

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Bell Laboratories Record

Volume Six MARCH, 1928 *Number One*

A New Loud-Speaking Receiver

By A. L. THURAS
Research Department

THERE has been developed in Bell Telephone Laboratories a loud-speaking receiver which differs in many respects from previous devices. In commercial form known as the Western Electric 555-W Receiver, the device has already found application to talking motion-pictures.

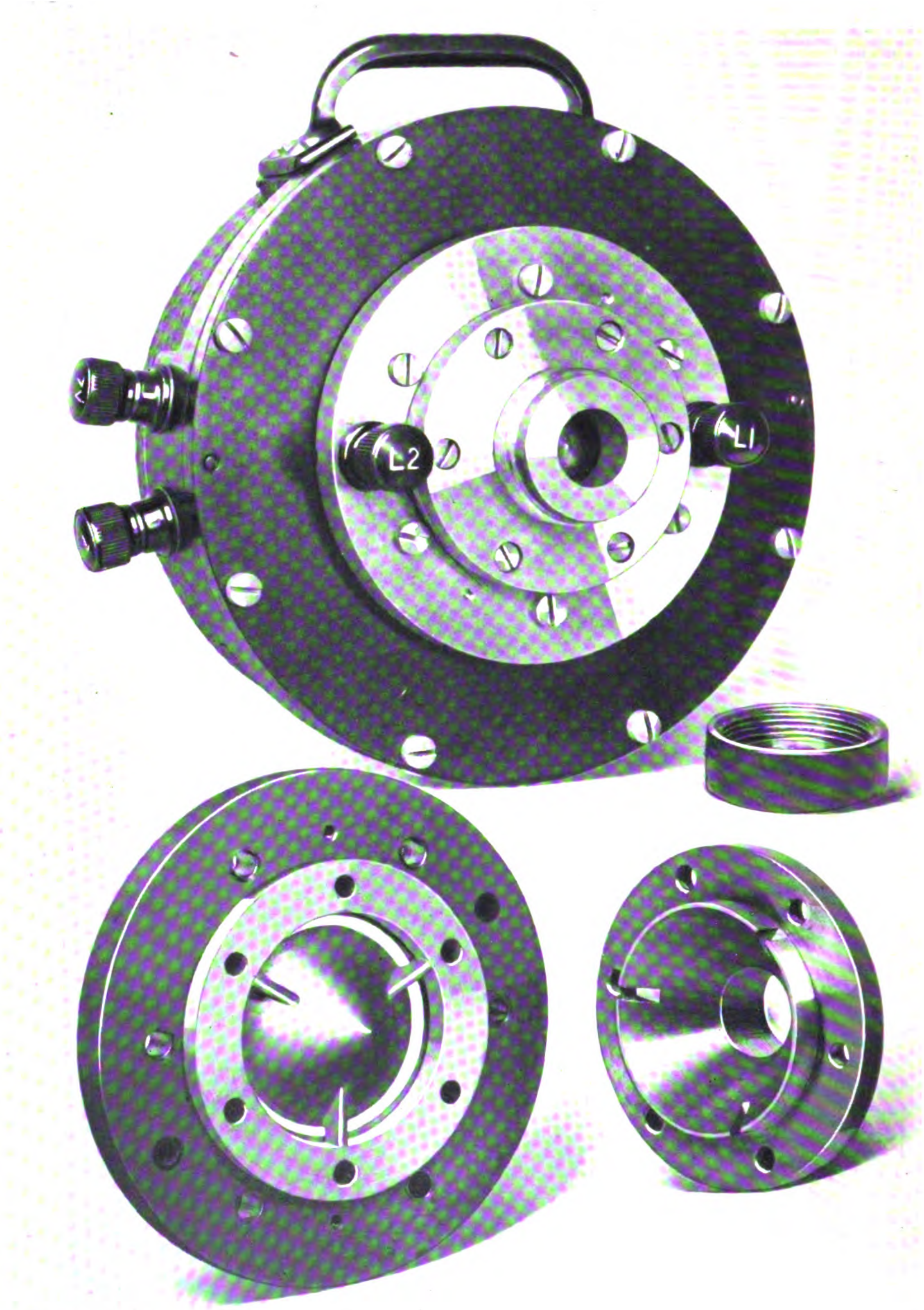
Briefly, the new receiver consists of a duralumin diaphragm to which is attached a coil of flat aluminum wire. Audio currents circulating in this coil interact with a steady magnetic field, forcing the diaphragm in and out of an air-chamber of novel form. Air-waves thus set up are radiated through a horn.

One of the things which may limit the sound-radiating efficiency of the horn type of loud speaker is interference between air waves as they pass through the chamber between the diaphragm and the throat of the horn. In many forms of loud speaker, the dimensions of this chamber are comparable with wave-lengths of sound within the audible range. To avoid this effect, and the resultant irregularities in the frequency-response curve, the air chamber in this receiver is so constructed that no serious phase-differences can occur within the useful range of wave-lengths.

Another factor which has come out of development studies on receivers is the desirability of having the diaphragm vibrate to and fro as nearly like a rigid plunger as possible. An ordinary flat piece of metal clamped around a circular edge assumes a domed shape when vibrating at low frequencies. The diaphragm can be made to vibrate with its central portion essentially unflexed by adopting a shape which makes it less rigid near the edge and more rigid toward the center and then applying the force uniformly around the outside of the central portion.

These things are accomplished by the shape of diaphragm illustrated in Figure 1. It is made of a single piece of sheet aluminum alloy 0.002 inch thick. To this is fastened a driving

EDITOR'S NOTE: *The definitive technical presentation of this development appears in an article by E. C. Wente and A. L. Thuras in Bell System Technical Journal for January, 1928.*



Above, the Western Electric No. 555-W Receiver ready to be attached to a horn; below, the horn-coupling opened to show the novel form of the air chamber

coil of circular form, indicated by (B) in Figure 1. This coil, which is itself of a novel type, is mounted rigidly on the diaphgram. In the assembled receiver it moves up and down in the annular space between the ring-shaped pole pieces of an electromagnet. Between the coil and the clamped edge, the diaphragm is corrugated tangentially to prevent resonance. This idea was developed in the Laboratories by H. C. Harrison and is incorporated in the sound-box now used by the Victor Talking Machine Company.

The driving coil (B) is a single layer of aluminum ribbon 0.015 inch wide and 0.002 inch thick wound *on edge*. The turns are held together by a thin film of insulating lacquer about 0.0002 inch thick which is thoroughly baked after the winding is completed. Thus the coil becomes mechanically self-supporting, and rigid, and is very light. Ninety per cent of its volume is occupied by metal, and since the metal is continuous between the outer and inner surfaces, heat is conducted outward quite readily so that larger power input can be used without danger of warping through overheating. There is but a single layer, and so the distributed capacity of the coil is very small. Partly for this reason, the impedance of the coil is a resistance nearly constant with frequency—a factor in

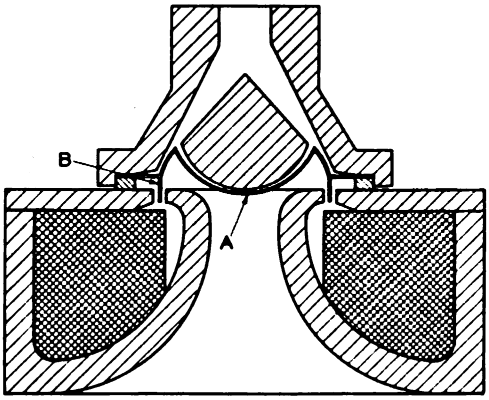


Fig. 1.—*A sectional view of the loud speaker: A, the diaphragm; B, the driving coil*

the flatness of the frequency-response curve. Aluminum was selected instead of copper because its much smaller weight yielded less mass-reactance at high frequencies. The resulting gain in efficiency at the upper end of the spectrum more than counterbalanced

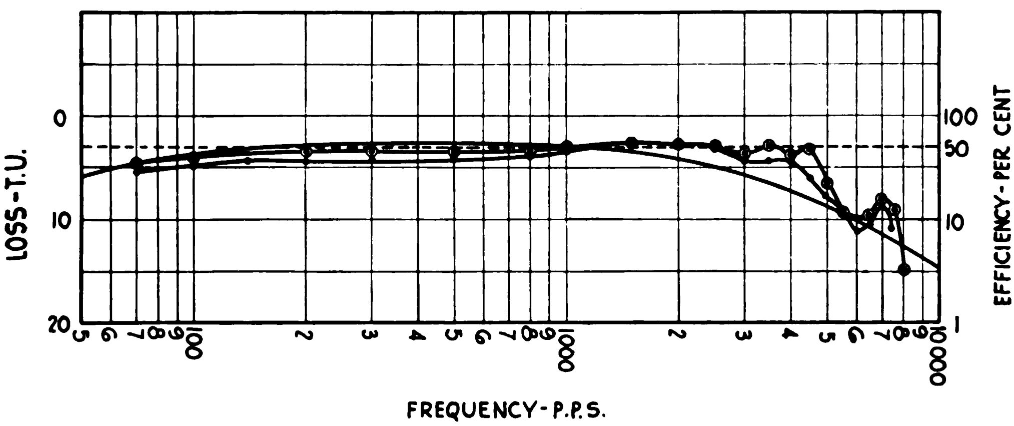


Fig. 2—*Performance of the* 555-*W Receiver. The solid curve was calculated; the other curves represent actual measurements*



Details of the 555-W Receiver. At top, the receiver separated at the air-gap. The driving coil is seen attached to the diaphragm. Below, the diaphragm and its mounting-plate separated as the leaves of an opened book. At bottom, the progressive assembly of the coil on the diaphragm

the somewhat increased electrical loss.

The manufacture of the coils is a story in itself which is to be told in a later issue of the RECORD. It has been shown that it is feasible to make the coils in quantities within narrow tolerances so that very small clearance between the coil and the electromagnet can be obtained. Small clearance facilitates the dissipation of heat and makes more effective use of the steady field so that a smaller magnetizing force can be used. Studies were made of both permanent and electromagnets as the source of the steady field; the electromagnet was adopted for the commercial receiver.

An outstanding feature of the receiver is the high efficiency with which it converts power from that of electricity to that of sound. For the experimental model, efficiencies as high as fifty per cent are realized. When it is recalled that the resulting sound intensities are only three transmission units lower than those to be obtained at one hundred per cent efficiency, it will be understood that little is to be gained from any further increase in efficiency, except in so far as reduction in the percentage of loss enables greater power to be handled without exceeding a safe operating temperature. When coupled to a suitable horn, fifteen watts of sound power can be radiated.

Variation of efficiency with frequency was measured by two methods. The results are given in Figure 2 where the efficiency is expressed both in percentages and as TU below the ideal maximum of 100 per cent. The smooth curve in this figure is calculated theoretically from the mechanical and electrical constants of the system. The tests are seen to agree well with theory except for some irregularities at the high-frequency side. As the actual efficiencies are above the theoretical the receiver unit



The 555-W Receiver is tested by connecting it to a long tube and measuring its input to this acoustic "line" by the condenser transmitter shown on top of the tube. Theodore Osmer had a large part in the development work

may be said to have exceeded expectations for these frequencies.

At high frequencies the power output is limited solely by the current-carrying capacity of the coil. A temperature rise of one hundred degrees centigrade in the coil is allowable, corresponding to a continuous power input of thirty watts. This means fifteen watts of sound power at fifty per cent efficiency.

Step-By-Step Cordless "B" Board

By W. J. LACERTE
Systems Development Department

IN the course of converting the telephone equipment of a community to a dial basis, it is necessary during the transition to handle calls in both directions between the older manual and the newer mechanical offices. And even when complete conversion to machine-switching takes place, it will still be necessary to transfer many toll calls, incoming and outgoing, between the two types of equipment. For traffic originating at machine-switching offices the electrical signals are translated into numbers displayed before an operator at the distant manual office or at an intervening manual tandem center. In the other direction, calls to panel offices have long been translated into the machine's language by depression of keys provided at an incoming trunk board* in the machine-switching office. Until recently, however, step-by-step offices have received their incoming calls from manual offices by dialed signals from those offices, the arrangement being known as the "out-dialing trunk" system.

From operating and traffic standpoints this procedure is quite satisfactory, but under certain conditions recently encountered it does not bring about the most efficient use of equipment. In addition to modification of trunks to the step-by-step offices, it necessitates provision of dials at all subscribers' and tandem switchboard positions and dialing equipment on all the cords. That arrangement is the most economical in a small community, but for a step-by-step office near a large metropolitan area it involves a large investment in dialing equipment at the manual offices, used in most cases on a comparatively small part of the outgoing calls.

For such situations a cordless incoming-trunk board is now available, which concentrates the facilities for conversion of the calls at the step-by-step office, where the incoming calls converge. The first installation is in service at McKeesport, Pennsylvania, a manufacturing city in the Pittsburgh district served by a step-by-step office. With its use no modification of manual switchboards or trunks is needed to permit completion of calls from subscribers in Pittsburgh or its trunking area. The originating operator's work is the same as with a straightforward call to a manual subscriber. The call is transferred to machine-switching equipment at the terminating office, and at that office all the necessary equipment is located.

For the calling subscriber there is no indication that his call is receiving special handling. His operator asks him for the number wanted; after she acknowledges it, he hears the order signal, the same "zip-zip" tone used in manual practice. Thereupon the "A" operator states the number

* *For the same purpose, equivalent key equipment may be installed instead at each A-board position.*

wanted, and thus finishes her work until the conversation is finished; after a short interval the calling subscriber hears the ringing signal which indicates to him that connection has been completed as far as the line of the person wanted. But he has had no intimation that the connection has taken place through step-by-step switches, or been guided by controlling circuits of machine-switching equipment.

At the terminating office is a "completing" operator who receives and acknowledges the order just as a manual "B" operator would. Through a group of ten numerical keys she communicates the number to the completing switches, pressing in turn the keys corresponding to the successive digits. Her headset is connected and disconnected automatically by the circuit equipment; hence she has no allotting keys, and hence likewise she exercises no supervision over the call. At her position are two switchboard lamps, showing progress of the call, and three additional keys. One key, if pressed before the last digit has been recorded, stops the call and resets the recording equipment so that she can rectify an error if it is noticed in time; another, for use when her position is not disconnected automatically at the completion of the pulsing, releases it and makes it available for the next call; the remaining key is used to summon the supervisor when she is wanted. Removal of the operator's plug directs calls to the occupied positions.

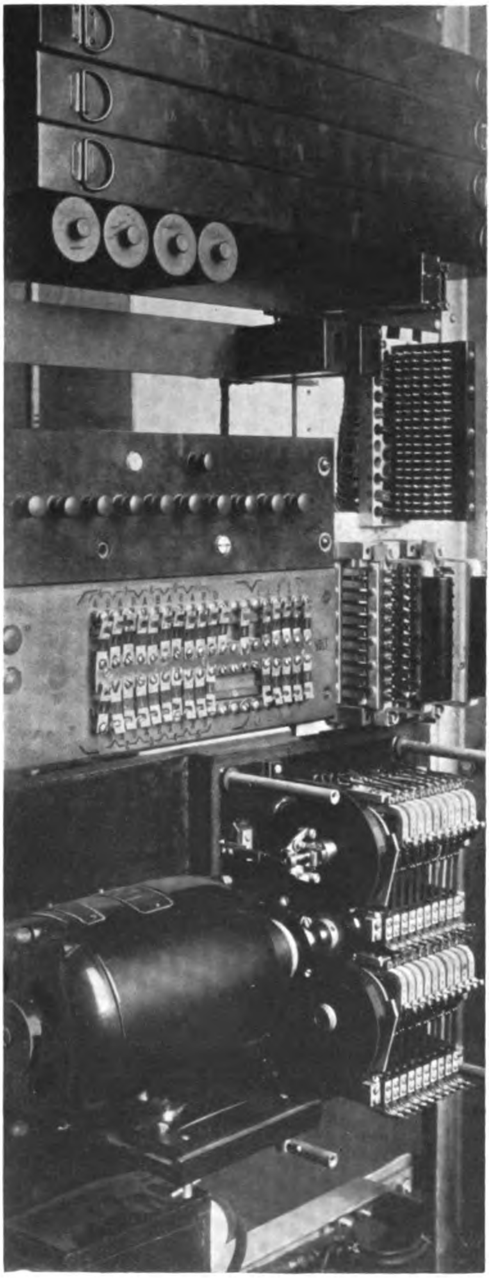
The complete cordless equipment aside from the operator's position is made up of six principal parts, shown on the accompanying chart, whose functions are indicated by their names.



Two operators' positions. At the left is a section in which the cable comes up from the floor

One branch of each incoming trunk, through which conversation takes place, is permanently attached to a first selector; the other branch runs to the cordless "B" equipment, whereby movements of the step-by-step switches are governed. These controlling branches terminate on trunk-finder switches by which the necessary switch-controlling mechanism is connected during completion of each call, and then freed for use on other trunks; the trunk finders are standard step-by-step type switches, but with six hundred terminals and a vertical commutator. A circuit of six conductors is required; hence the terminal capacity of each trunk finder is one hundred trunks, and for each hun-

dred incoming trunks a group of finder switches is provided, depending in size on busy-hour traffic. There are ten levels to the trunk-finder bank, with ten trunks on each. To minimize hunting time and to prevent discrimination between subscribers the trunks are terminated on different levels of the several finder switches, allowing each trunk to appear on the first level at least once; the circuit which starts the switches will choose that one on which the incoming call appears at the first level, if it is not busy.



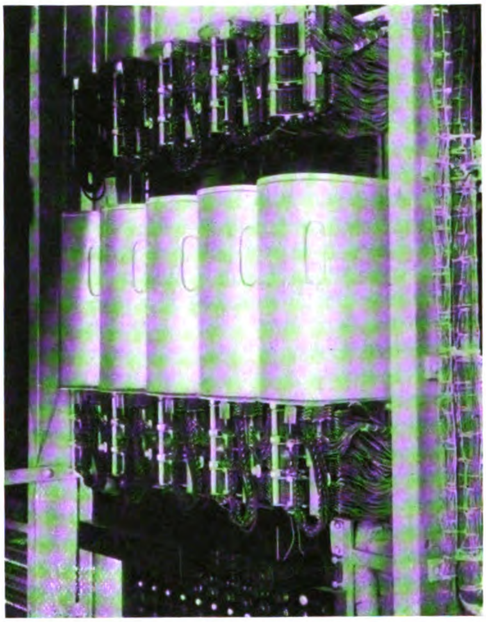
Lower section of sender frame, showing the motor and the interrupter with cover removed

Each trunk finder is a permanent part of a link circuit, the heart of the system. The other two parts of each link are two 200-type selectors; on one of these are terminated lines to the operator's positions and on the other lines to the senders. Governing both, and governing the trunk finder as well, are control circuits to start these hunting switches at the proper moment. This link circuit ties the incoming trunk, through the trunk finder, to the completing operator and the sender, and thereby allows the call to advance from an order passed by the "A" operator to a setting of relays in the sender, which in turn controls the mechanical completion of the call.

The sender, an innovation in step-by-step practice, increases the operator's load to her working capacity, freeing her from limitation by the speed of the completing selectors and connector. Its function, like that of the senders in panel equipment, is to receive and record the number set up, and to send out a series of pulses guiding the operation of the step-by-step completing switches as each in turn is called upon to function. The sender is suited alike for four- and five-digit numbers; it contains five groups of register relays, of which each group records one digit. Pulses are sent out by two sets of interrupter contacts

controlled by these register relays, to communicate the recorded number to the selector and connector switches. Of these contacts, one set functions the same as the pulsing contacts of a dial, and the other controls counting mechanism to terminate each group of pulses when the proper number have been sent. Connection of the sender to the link circuit through a searching switch, rather than by a permanent contact, provides equipment economy to a marked degree. The McKeesport installation requires eighteen link circuits, but on account of reduced sender holding time secured by the use of sender selectors and the higher efficiency of group operation, it requires no more than ten senders.

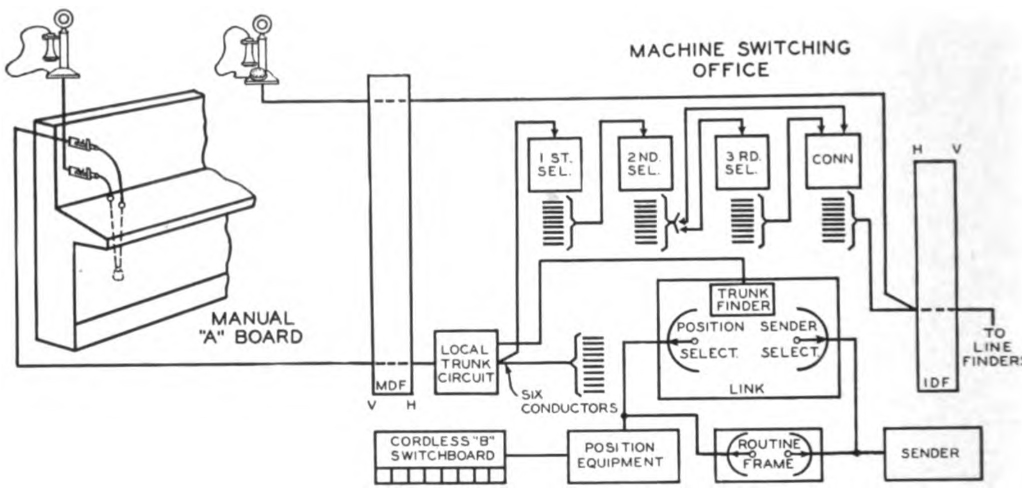
Possibly the best explanation of the system would be to trace a call from a distant subscribers' or "A" board to completion. The "A" operator, receiving a call for a machine-switching office, chooses an idle trunk as in straightforward practice and plugs into the jack. Immediately at the completing end the trunk finder of one of the link circuits starts hunting for the trunk on which the call is waiting; almost simultaneously the position selector of the link begins searching for an idle operator's position, which it finds at about the time the trunk is located. Thereupon both "A" and "B" operators receive the order tone; the "B" operator is further notified that a call is coming by the lighting of her two switchboard lamps. As soon as the "B" operator's position has been connected, the link's controlling equipment disconnects from the position selector and guides the sender selector in choosing an idle sender. About the time the order has been passed and acknowledged, the idle sender has been found, whereupon one lamp is extinguished to indicate that everything is in readiness to record the number and to pass it on to the step-by-step equipment. The cordless "B" operator then registers the digits on



Trunk-finder switches

her numerical keys, pressing them successively and thereby recording on consecutive register relays of the sender the code to secure completion of the call; her position then is disconnected automatically. The first group of register relays controls pulses sent to the first selector and the second group those sent to the second selector, and so forth, until the brushes of the connector are stopped at the terminals of the called station. Then, the connection completed except for lifting of the receiver by the called subscriber, the work of the link circuit and its associated equipment is done. At once the trunk finder and sender selector re-

lease their contacts, freeing for other calls the circuit-controlling equipment. But the connection to the called station from the incoming trunk through its permanently joined sending and to disconnect within a few seconds after the operator's position has been released, and by other operating and equipment difficulties. Attention of maintenance men is



Schematic diagram of the cordless "B" switchboard

first selector remains, ready for conversation.

On account of the large number of operations taking place in a few seconds — action of approximately two hundred relays and in addition a few manual and several switch operations — reliable means for prompt detection of trouble is most important. There are therefore audible alarms for trouble of various sorts — alarms operated by a melted fuse, by failure of the trunk finder to function within a predetermined maximum time, by an excessive link-holding time, by failure of the sender to finish its pulse- thereby called immediately to points needing attention, and service delay is prevented.

Although it includes previously known elements, the step-by-step cordless "B" board marks a distinct advance in conversion of calls from manual offices, particularly in certain communities adjoining large cities. Conversion of calls to panel and step-by-step dial offices is placed on a closely comparable basis. Most important, wherever suited to the operating needs of a community the board provides greater over-all economy of facilities than was formerly attainable.

New Devices in Television

MEMBERS of the American Physical Society and the American Optical Society meeting in our auditorium on Saturday, February 25, witnessed a demonstration of television during which were shown important new developments which remove some of the many conspicuous obstacles now separating the television art from any important commercial applications.

Heretofore syncronization between the sending and receiving apparatus has been accomplished by a signal transmitted from one device to the other. Electric oscillators controlled by vibrating quartz crystals have now been developed which permit two stations to be held in synchronization without being connected to a common control, and which also permit of making the preliminary adjustment known as framing in an extremely simple way. These crystal control oscillators are the development of J. W. Horton and W. A. Marrison and are capable of holding to a constant frequency within one part in ten million.

Such oscillators were originally developed for other purposes in the communication art, as for instance the precision measurement of frequency. They have just been applied to television for the first time and provide simple and effective synchronization. When controlled by these crystals, the driving motor of the receiver would require one week to get out of step with the motor at the sender by as much as one revolution. In an hour the television image will, at most, wander only one-third of the distance across the field of view. The maintenance of a television image "in frame" therefore requires only occasional attention from those viewing it.

The new system also simplifies the original centering of the image within the viewing aperture. By the operation of two push buttons, the image can be caused to travel slowly across the field of view in either direction, and when it arrives at the desired position within the frame, release of the buttons automatically locks it in place.

The system not only involves crystal-controlled oscillators, but frequency-reducing circuits, recently developed by Mr. Marrison, which will generate from any vacuum tube oscillator a current whose frequency is a simple fraction of it such as a quarter, a fifth or a sixth. There is as well a device for introducing into the synchronous motor an additional positive or negative cycle at a very slow rate, to change the speed of the motor gradually and thus to effect the desired framing operation under perfect control of the operator.

Radio Installations in South America

By D. H. NEWMAN
Apparatus Development Department

WITH perhaps a greater appreciation of music and the fine arts than we have, our Latin American neighbors have not yet contracted that avid zeal for advertising and publicity which is the real incentive to the great multiplication of broadcasting stations existing in this country. Basking in the radiations from the six hundred and fifty and more stations of the United States, we sometimes fail to realize that on the entire continent to the south of us there are probably less than two score broadcasting stations. This is typical of the many differences that exist between the North and South American continents. Climatically they are radically different. Excepting the southern part of Mexico, no part of North America is in the tropics while South America is about two-thirds tropical. The peoples and customs of the southern continent also are distinctly different from those of the United States and Canada. Industrialism and high-powered salesmanship while beginning to invade the southern republics are still far from vitally affecting the lives of the bulk of the population.

These differences have been brought closer to the Laboratories within the last two years because of the installation of standard Western Electric broadcasting stations in five cities of the republics to the south of us. The work was supervised by members of the Laboratories' technical staff acting for the International Standard Electric Corporation. The first to be installed was in Caracas, the capital of Venezuela. This subtropical republic at the northern end of South America includes the rich Orinoco Valley and while largely mountainous contains much valuable grazing land. As is the case all over Latin America there is a big contrast in Venezuela between life in the cities and that in the country districts. This is well illustrated by the two accompanying photographs, one showing a quiet street in the capital and the other a thatched hut in the interior. In the cities, although the architecture is different from ours and life is less complex and moves more slowly, the modern spirit is evident, but in the smaller towns and agricultural areas life is more or less uncontaminated by twentieth century inventions, and the implements of industry are still primitive.

Until recently no radio apparatus has been allowed to enter Venezuela but a short time ago the government granted a monopoly to the Empresa Venezolana Radio Telefonica. This Company is now importing receiving sets and has installed a one-kilowatt broadcasting station to transmit programs of local and national interest which, it is hoped, will develop a demand for their sets. The station is housed in a three-room building beside the principal bull-ring. The studios, about a block away in a

private dwelling, are connected to the station by suitable cable circuits. One of the features to be broadcast is music by the Presidential Band, which plays in the Plaza Bolivar in the center of the city.

Following the installation at Caracas another was made in the republic of Haiti in the West Indies. In this country a traveler from the north sees much of a primitive character to marvel at. The photographs of the horse-driven sugar mill, built with Biblical simplicity in its setting of tropical shrubbery, and of the hand-power lathes, with their large driving-wheels lined up along a modern concrete road for contrast, show to what a great extent modern progress has passed Haiti by. The natives of African descent still cling to many of their Voodoo practices. Evidence of this is the rectangular niches in the sides of the tombs shown in the accompanying photograph. Into these recesses is placed food for the departed spirit as a form of propitiatory offering. Curiously enough it is the custom to mix poison or powdered glass with the food so that if the ghost should partake of it, a second death would send it back to the tomb for the time at least.



Map of South America and the West Indies showing the location of the recent installations of Western Electric sets

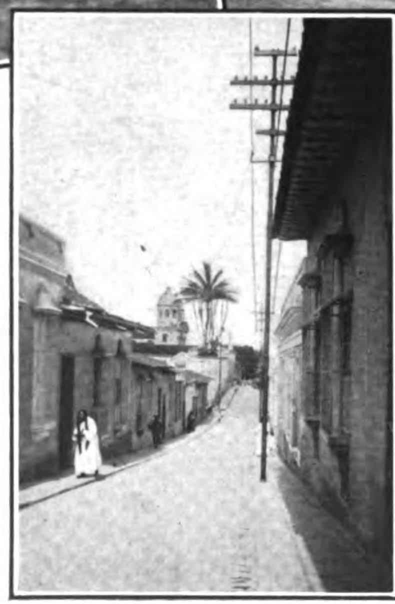
The station is located in Port-au-Prince, capital of the country, and is owned by the Government. It is operated by the Department of Public Works which purposes to broadcast lectures on hygiene, sanitation, and methods of planting, cultivating, and harvesting the national agricultural products which are very largely coffee and sugar. In the principal towns and villages radio receivers operating into public-address systems are set up in the markets where the



A native thatched hut in the mountains of Venezuela



A noon day meal in Montevideo. Note the shovel serving as a frying-pan



A quiet street in the Venezuelan city of Caracas

citizens congregate. In this way the government hopes to reach the greater part of the people who, because very few of them can read or write, could not well be reached in any other manner. Radio will thus serve Haiti as a very effective educating force.

While the author was installing these stations in Caracas and Port-au-Prince, a similar set was being installed, also under direction from the Laboratories, in São Paulo, the center of the coffee trade of Brazil and capital of the State of São Paulo. The Brazilian St. Paul is the richest city in the country and one of the most modern and progressive of all South America. The station is privately owned, being operated by a large group of amateurs known as the Sociedade Radio Educatora Paulista.

Brazil, the largest country in South America and almost equalling in size the United States and Alaska combined, is unique among all the South and Central American Republics in having Portuguese instead of Spanish as the national language. Two years after Columbus' first voyage a treaty





Negroes turning the large wheels which drive lathes in the huts by means of a rope belt



Making sugar in the Republic of Haiti



Top, a Haitian cemetery; below, radio station at Caracas

was signed by Spain and Portugal which established an imaginary line running north and south about eighteen degrees west of the Cape Verde Islands. All new land discovered west of this line was to belong to Spain and all east to Portugal. While there were some minor infractions of the treaty, nevertheless it has been for the most part observed. Under it Brazil was the only South American land falling to the lot of Portugal.

On the way south the tropics are left at São Paulo, for through the northern part of this city runs the Tropic of Capricorn. Uruguay, just south of Brazil, is wholly in the South Temperate Zone. It is semi-tropical, however, and like Los Angeles and southern California or Florida has palm trees, rainy seasons, and other evidences of equatorial climate. Montevideo, its capital city, stands on the north side of La Plata, the

great estuary of the Parana and Uruguay Rivers, which separates it from the Argentine Republic. The new station, which is government-owned, is located in this city on property belonging to the Escuela Militar, the West Point of Uruguay. The programs will be largely educational, probably including lectures from the national university. Although there are many who take pride in their pure Spanish ancestry the larger portion of the people of Uruguay, as of most of the South American republics, are a mixture of Spanish or Portuguese with the native Indians and former negro slaves. For the most part the working classes take life easily and make the most of what they have, as may be seen from the acompanying photograph where a shovel, used during the forenoon for digging the foundation of the new broadcasting station, is being utilized during the breakfast hour for frying beef steak. No faintest echo of the modern cry for cleanliness has yet reached their ears and should it finally do so would perhaps have little attention paid to it. The gasolene can beside them probably contains water for making maté, the native substitute for tea so commonly used in Uruguay, Brazil, and other parts of South America.

The last of the series of five southern stations is at Buenos Aires, capital of the Argentine Republic. This is the largest station of the group, being rated at five kilowatts. It is owned and operated by the municipality and will broadcast music from the famous Colon Opera House during the season. Out of the opera season various concerts will be broadcast and possibly also the proceedings of the City Council. The station is located on low lands which are often flooded by the waters of La Plata and due to this, construction work was considerably hampered. For each tower it was necessary to build a concrete platform nine hundred square feet in area.

Buenos Aires, or B. A. as it is popularly called, is probably the most modern and is the largest city in the entire continent. It is one of the few in South America that have had broadcasting stations for some time, so it is gratifying to know that its newest and largest is a "Western Electric."

Water Cooling for Radio

By J. O. GARGAN
Apparatus Development Department

TO dispose of the heat generated in vacuum tubes of a high-power broadcasting station is a problem none the less real for all that it is seldom appreciated by radio listeners. Heat is continuously generated not only by filaments consuming as much as twelve hundred watts each but by the bombardment of the plates by electrons moving at high velocity.

In smaller tubes the heat is radiated from the plate and taken from the glass enclosure by the surrounding air fast enough to keep the temperature down to a suitable value. As filament and plate currents and plate voltages are increased, however, heat is produced at such a rate that air cooling is no longer adequate. The limitation thus imposed on the power capacity of tubes was removed by the development and introduction of water-cooled tubes, and this in turn made the high-power radio transmitter commercially feasible.

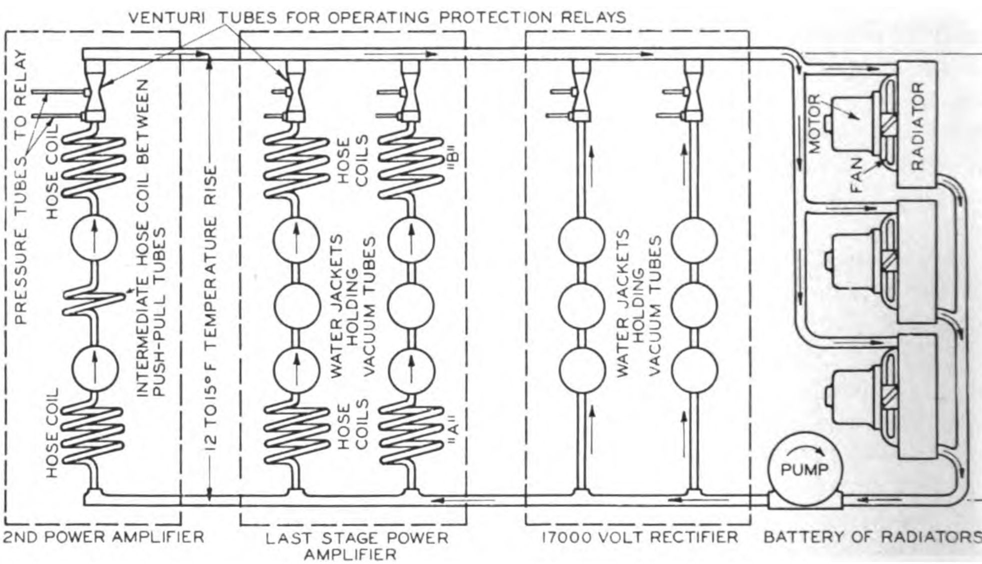
The water-cooled tube differs from the more familiar air-cooled tube in the construction and location of the plate or anode element. This is of copper, cylindrical in form and closed at one end; at the other end it is welded to the glass wall of which it forms an extension so that the tube shell or envelope consists partly of the anode itself. Within it are suspended the grid and the filament, for which leads are brought in through the glass-enclosed end of the tube. In use, the tubular anode is inserted and clamped in a suitable metal water jacket through which the cooling water circulates in direct contact with the anode. Through its water jacket the anode is also connected electrically to the plate circuit.

Much of the fundamental design work in connection with water cooling was put into commercial application several years ago when the first Western Electric five-kilowatt sets were installed. The cooling system employed in the fifty-kilowatt set at Whippany is the result of further study based on electric, hydraulic, and thermal considerations.

In this transmitter a total of twenty-five tubes are employed, of which fourteen are water-cooled. Six of the latter are rectifiers for providing plate current to the other eight which are used for the last stages of amplification. The total heat generated in fourteen tubes due to filament heating and electronic impact is equivalent to 185 kilowatts or about 250 horsepower. This amount of heat must be transferred to the cooling water from anode surfaces which total only four square feet for the fourteen tubes. In a steam boiler the heating surface transferring an equivalent amount of heat would generally be over two hundred square feet. In the tubes at Whippany, which have the same anode surfaces as do the tubes

of the five-kilowatt transmitter, four times as much energy must be transferred. To meet this condition satisfactorily has required the design and adoption of a new type of water jacket in which a thin cylindrical sheet of water passes over the anode surface at very high velocity. Thus a larger part of the heat is transferred to the water by direct contact with the surface of the anode and much less of the transfer is dependent on convection within the jacket.

Anodes and water jackets of the amplifier tubes are maintained at a potential of 17,000 volts above ground. To restrict leakage of current from the jackets to the grounded pipes of the system, connection is made through lengths of coiled hose so that there are interposed columns of water long enough to make the electrical resistance to ground a matter of hundreds of thousands of ohms. Unfortunately, conditions making for high electrical resistance make for large hydraulic resistance as well. To maintain the necessary rate of flow without requiring excessive power for pumping and without endangering the comparatively thin copper anode by crushing from excessive water pressure, it is necessary to compromise and to use hose of length and diameter moderately satisfactory from both the electrical and hydraulic standpoints rather than ideal from either consideration. In the second power amplifier, which employs two tubes, a total of seventy feet of 3/4″ hose is used and in the six-tube power stage, there are one hundred and thirty feet of 1″ hose. The effective resistance of the two parallel paths of distilled water in the small amplifier unit is approximately 2,000,000 ohms and in the larger amplifier where there are four parallel paths for leakage, the resistance is about 300,000 ohms. The direct current losses through these are about 150 watts and 1000 watts respectively.

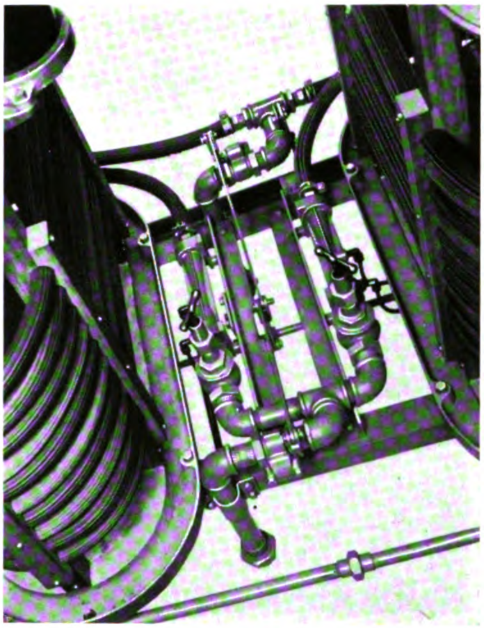


Schematic diagram of the cooling system

The water jackets and anodes of

the rectifier tubes are at ground potential so that water connections to the supply pipe can be made directly.

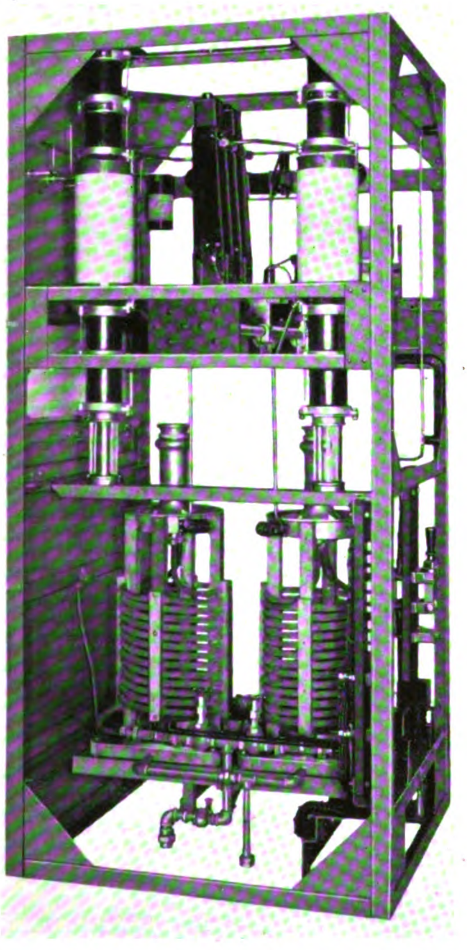
To avoid formations like boiler scale on the anode surface, and also to obtain high electrical resistance, distilled water is used for cooling. Obviously, for economic reasons the same water must be used indefinitely. It is therefore cooled in three large tubular radiators through which each minute 25,000 cubic feet of air are forced by motor-driven fans. The water-circulating pump and the fans are stopped and started automatically with the transmitter from the power panel. In its passage the air is heated about 25° F. At a station operating regularly, the air could be distributed



Venturi tubes at the ends of two hose coils

through ducts to various parts of the building and used for heating, but at Whippany irregular operation makes this plan impracticable. The heated air is therefore blown out of the building through louvers.

Because the amount of dissipated energy differs in each of the various groups of vacuum tubes, for the same temperature rise each group must receive only its proportional amount of water flow. The hydraulic resistance of each of the paths through which the water can flow from the pump to the radiator is therefore designed to give the flow wanted, just as the impedance in an electrical network can be designed to govern the current through it. In the present system the rate of flow is about one hundred gallons per minute.



Frame of one of the panels, containing water jackets for two tubes

In case of interruption or reduction of the flow the tubes must be instantly and reliably protected at each anode from the dangerous heating effects of the large amount of energy liberated. Such protection requires automatic disconnection of the power supply. Each branch of the hydraulic network therefore contains a Venturi tube whose inlet and throat orifices are connected to a device containing two opposed metallic bellows. These are operated by the difference in pressure established between the two orifices by the flowing water and when the flow is normal close an electrical contactor to the power service. If the flow is interrupted or if it falls to seventy per cent of normal in any branch, the bellows at once open the contactor and disconnect the power.*



The radiators and pump

To a visitor in the transmitter room at Whippany, there is little to indicate that there is such an extensive cooling system. Three dials on one of the panels are the only measuring devices to be seen. Two are thermometers indicating respectively the temperatures of the water as it enters and leaves the jackets. From readings of these and of small pressure gauges attached to the inlets and throats of the Venturi tubes, the rate at which energy is being dissipated at any time can be computed. On these thermometers are electric contacts which give an alarm if the water heats to an undesirable point; then, if the rise in temperature continues, shut the set down completely. The third dial on the panel is a pressure gauge to indicate whether the pump is operating properly. The water jackets can be seen through the panel windows, but to the casual observer they appear to be parts of the tubes themselves. The hose coils and their accessories are at the back of the panels and the expansion tank with valves and fittings is in a corner of the room. The pump and radiators are at a dis-

** The bellows and the protective relay which they operate were described by the writer in the "Record" for February, 1926.*

tance in another wing of the building.

After distilled water is used for a considerable period of time, it may absorb enough impurities from the metallic surfaces it touches to lower its resistance considerably. For that reason a milliammeter is provided in one of the panels which indicates to the operator, whenever the equipment is in operation, the magnitude of the current leaking through one of the hose coils and thereby warns him when it is advisable to change the water. Special precautions have been taken in the plumbing to avoid entrapping air when filling the system since air bubbles clinging to the anode surfaces hinder satisfactory cooling. In addition, valves have been provided for removing occluded air which has been liberated from the water during heating.

FORMS OF LIFE INSURANCE

I. Ordinary Life

The person who carries an ordinary or "straight life" policy pays for it during his entire life, and at his death the policy becomes payable to the beneficiary. However, the insurance company credits the policy-holder annually with a share in its profits, and if these dividends are left with the company, in about twenty-one years the policy becomes fully paid. Dividends continue to be paid but there are no further premiums. After the first year the policy has a value which the company will pay in cash if the policy is canceled, or it will lend this sum at interest, the policy remaining in force. The cash value increases from year to year.

Life insurance takes so many forms adapting itself to many individual needs that its consideration becomes a matter where expert advice is necessary and desirable. The Laboratories have, therefore, arranged to have a specialist in life insurance, Mr. L. H. Bunting, stationed at West Street who may be freely consulted by any employee. Mr. Bunting is to be found in Room 144 *and may be reached on Telephone* 264.

Report on Employees' Benefit Fund

BELL TELEPHONE LABORATORIES, INCORPORATED

January 1 — December 31, 1927

IN common with other companies of the Bell System, the Laboratories has maintained a Plan for Employees' Pensions, Disability Benefits and Death Benefits. By action of the Board of Directors, a change effective as of January 1, 1927, has been made in the method of providing funds for the payment of service pensions to employees retired from active service under the terms of the Plan. This change does not, in any way, affect the amount of the pensions or other benefits payable under the Plan, but is of real importance as a progressive and forward looking development of the pension system, to meet adequately the future demands upon it.

Although the number of retired employees of the Laboratories is still small, the increase in this group which lies ahead has been foreseen and a method has been developed for making financial provision for the increasing pension payments which will accompany this growth, so as to place added security behind the terms of the Employees' Benefit Plan relating to service pensions. Under the arrangements which have now been made, a Pension Fund, segregated from the assets of the Laboratories, will be built up by systematic charges to operating expenses which will be made each year. These charges will be so computed that when employees become eligible to retire on pension at their own requests [that is, under paragraph 1 (a) of Section 5 of the Plan] there will be available in the Pension Fund a sum which, with the interest it will earn, will be sufficient to provide a life pension of the amount stated in the Plan.

The Pension Fund will be held by a trustee solely to meet service pension obligations of the Laboratories for employees who are retired. Pensions which became effective prior to January 1, 1927, will be charged to the Employees' Benefit Fund Reserve and the amount of the Reserve will be reduced as such charges are made. Service pensions which became effective on or after January 1, 1927, will be charged to the newly established Pension Fund. Checks for pension payments will continue to come direct from the Laboratories, as heretofore.

The arrangements which have been made, as described above, are an added surety for the integrity of the pension plan.

By reason of the foregoing it is no longer necessary to increase the Benefit Fund by monthly accruals of 1% of the payroll. Accordingly, pursuant to further action by the Board of Directors, the sixth paragraph of Section 11 of the Plan for Employees' Pensions, Disability Benefits and Death Benefits was amended, effective

January 1, 1927, omitting the provision for setting aside in the Benefit Fund at the end of each month 1% of the payroll, and providing for the reimbursement of the Fund at the end of the fiscal year with such amount as will restore the Fund to its amount at the beginning of the year less service pension payments made during the year in respect to service pensions to employees who retired prior to January 1, 1927.

In accordance with the foregoing and as prescribed in paragraph 4 of Section 3 of the Plan for Employees' Pensions, Disability Benefits and Death Benefits, following is the record of receipts and disbursements for the year affecting the Benefit Fund:

Balance in Fund as of January 1, 1927	$186,688.11
Additions to Fund during Calendar Year 1927:	
Interest at 4%	5,794.88
Amount Added to restore Fund to its amount as of January 1, 1927, less Service Pensions to employees who retired prior to January 1, 1927	79,576.09
Total Credits	$272,059.08
Disbursements from Fund during Calendar Year 1927:	
Service Pensions to employees who retired prior to January 1, 1927	$ 1,274.88
Disability Pensions	1,668.41
Accident:	
Disability Benefits	5,567.60
Disability Expenses	519.05
Death Benefits	9,551.50
Sickness Disability Benefits	68,064.41
Total Disbursements	$ 86,645.85
Balance in Fund December 31, 1927	$185,413.23

J. E. MORAVEC,
General Auditor.

The above statement of Receipts and Disbursements audited and found correct.

WILLIAM R. REID,
Traveling Auditor for American Telephone and Telegraph Company.

News Notes

At the Midwinter Convention of the American Institute of Electrical Engineers, technical and scientific advances of the Bell System were recognized by presentation of the John Fritz Medal to John J. Carty, Vice-President of the American Telephone and Telegraph Company and Chairman of the Board of Bell Telephone Laboratories. The award was made "for pioneer achievement in telephone engineering and in the development of scientific research in the telephone art."

By use of the transatlantic telephone circuit, a joint meeting of the Institute was held with the Institution of Electrical Engineers in London. After papers by O. B. Blackwell and K. W. Waterson had described technical and traffic features, the circuit was set up so that each audience could hear speeches and applause in the other's auditorium. H. P. Charlesworth greeted Col. A. G. Lee, an engineer of the British Post Office, and introduced Bancroft Gherardi, President of the American Institute. Mr. Gherardi, after greeting Archibald Page, President of the British body, asked him to preside over both meetings. Mr. Page in turn called upon Dr. Jewett and Col. T. E. Purves, Engineer-in-Chief of the British Post Office. General Carty, in New York offered a resolution, which was seconded by Sir Oliver Lodge in London.

Called on for an address, Sir Oliver said:

"All those who in any degree have contributed to this result from Maxwell and Hertz downward, including all past members of the old British Society of Telegraph Engineers, will rejoice at this further development of the power of long-distance communication. Many causes have contributed to make it possible; that speech is transmissible at all is due to the invention of the telephone. That speech can be transmitted by ether waves is due to the invention of the valve and the harnessing of electrons for that purpose. That ether waves are constrained by the atmosphere to follow the curvature of the earth's surface is an unexpected bonus on the part of Providence, such as is sometimes vouchsafed in furtherance of human effort.

The actual achievement of today at which we rejoice and which posterity will utilize, must be credited to the enthusiastic cooperation owing to the scientific and engineering skill of many workers in the background whose names are not familiar to the public as well as to those who are well known.

The union and permanent friendliness of all branches of the English speaking race, now let us hope more firmly established than ever, is an asset of incalculable value to the whole of humanity. Let no words of hostility be ever spoken."

The joint meeting then adjourned.

In the afternoon, about 350 members and guests of the Institute visited our Auditorium as one of the inspection trips incident to the Convention. Here Donald MacKenzie described the various forms of talking motion-pictures, and H. E. Ives described and demonstrated the television system. The speakers were presented by John Mills following an introductory talk in which his voice was reproduced from a film record.

Two methods of sound recording were shown: one, now employed in the Movietone, uses a photographic film and a neon lamp glowing in synchronism with the sound. The other, that employed in Vitaphone, is a development of our Laboratories in which the sound is recorded on a wax disc.

At one of the technical sessions of the Convention a paper, "Manufacture and Magnetic Properties of Compressed Powdered Permalloy" was presented by W. J. Shackelton of the Laboratories and I. G. Barber of the Western Electric Company.

* * *

Mr. Jewett spoke at a luncheon of the New York Building Congress held on February 15 at the Hotel Commodore on "The Value of Research in Industry."

* * *

Mr. Craft has returned from a tour of the Pacific Coast during which he addressed twenty-nine representative gatherings. Among them were dinners given in his honor by local telephone officials, sections of the A. I. E. E., and electrical engineering departments of Oregon State College, the Universities of Washington and of California, Stanford University, and California Institute of Technology. At Stanford Mr. Craft was the guest of Harris J. Ryan and visited his high-tension laboratory. President R. A. Millikan was his host at California Tech. Mr. Craft's war-time interest in naval communications was recalled in conversations with the officers in charge of the San Diego Naval Base. Executives of the Pacific Telephone and Telegraph Company planned the details of the trip.

On the evening of February 14, 125 members of the New York Section of the American Society for Steel Treating visited the Laboratories and were greeted by F. F. Lucas and R. W. King. After a short talk by Mr. King on the work of the Laboratories, the guests were given a demonstration of Vitaphone and Movietone in the Auditorium, under the supervision of L. W. Davee, R. E. Kuebler, T. J. Engel and H. Jones, and then were taken to the Microscopic Laboratory where Mr. Lucas, H. A. Anderson, Anna K. Marshall and R. M. Sample demonstrated the equipment.

* * *

At the Colloquium Meeting February 6, A. W. Horton, Jr. spoke on Measurement of the Velocity of Light, and D. MacKenzie on Significance of Professor Miller's Ether Drift Measurements. J. M. Eglin spoke February 20, on The Physical Theory of Diffusion.

* * *

During a month's visit to the Pacific Coast, J. C. Hunsaker made a number of contacts with air transport companies, and discussed the requirements for communication which would grow out of their plans for expansion.

General Staff

S. P. Grace addressed the Minnesota Telephone Association on recent developments of the Laboratories and demonstrated speech inversion, at a meeting in Minneapolis on January 25. On January 27 he spoke before the Business Men's Association and the Rotary Club of the same city. Mr. Grace lectured on the same subject before the Wisconsin State Telephone Association in Milwaukee on February 8, and at the University of

Wisconsin on February 10. On February 24 he spoke before the City Club Forum of Washington, D. C.

Apparatus Development

K. O. Thorp and J. D. Sarros returned to New York, having spent the past three months assisting in the installation of power line carrier telephone apparatus for the Pacific Gas and Electric Company between Oakland and Pitt River. R. D. Gibson and C. N. Nebel remain on the Pacific Coast, to continue installation.

W. Fondiller spent the week of January 29 at Hawthorne in discussions of various new developments, particularly loading coils, magnetic materials and enamelled wire. On the trip he was the official host of Professor Michael Pupin, who went to Chicago to make several addresses and to receive the Washington award of the Western Society of Engineers. At Hawthorne Professor Pupin was received by C. L. Rice, Works Manager, and J. R. Shea, Superintendent of Development, and was shown noteworthy developments of recent years.

F. J. Given spent the week of January 23 at Hawthorne in connection with a new design of coil for use in filters of Type C carrier telephone systems, and improvements as to crosstalk of new permalloy dust core loading coils.

H. B. Arnold recently made a study of the Union Gas and Electric Company's power line carrier telephone system in Cincinnati, Ohio.

H. M. Stoller visited the Fort Wayne plant of the General Electric Company for the purpose of testing and approving two new types of motors to be used in production of talking moving pictures.

L. B. Cooke spent several days in Keysport, Tennessee, assisting the American Gas and Electric Company in the installation of a new power line carrier telephone terminal.

W. A. Evans inspected transfer switches of pulse machines at the Baring Exchange of the Bell Telephone Company of Pennsylvania.

P. Neill was in Hawthorne the week beginning January 29 for meetings of the Inspection Survey Committee in connection with the inspection of plugs and jacks.

H. S. Price supervised the installation of a new oscillator unit in the five-kilowatt broadcasting transmitter belonging to the U. S. Playing Card Company at Mason, Ohio.

W. L. Tierney supervised the installation of a five-kilowatt broadcasting transmitter for the Moody Bible Institute of Chicago. This is the second Western Electric Installation for this organization. Due to the excellent cooperation by the contractor and the customer, the new station was put in operation on the eighth day after Mr. Tierney's arrival—a new record for a job of this sort.

O. F. Forsberg visited in January the factory of the Northern Electric Company, Montreal, Canada, at the invitation of Mr. Adams, Chief Engineer. While in Montreal, he attended a conference of officials of the Bell Telephone Company of Canada and the Northern Electric Company for a discussion of dials.

W. C. Ellis, W. Fondiller, C. H. Greenall, J. E. Harris, W. S. Hayford, C. H. Mathewson, E. E. Schumacher, J. R. Townsend and H. N. VanDeusen represented the Laboratories at a conference of the joint Bell System — American Brass Company committee which is working out specifications for non-ferrous

sheet materials, such as bronze, nickel silver and brass. The meetings were held at the Laboratories February 16 and 17.

H. A. ANDERSON spent February 16 to 18 in Montreal in attendance at the Winter Meeting of the American Society for Steel Treating. He also visited the Northern Electric Company and discussed copper wire problems with them. During the month of January, Mr. Anderson and J. B. Mudge of Hawthorne visited the Rathbone Company of Palmer, Massachusetts, and the American Steel and Wire Company of Worcester to discuss the production of pinion wire for parts for operators' calling dials.

H. A. ANDERSON is Chairman, and J. R. Townsend and F. F. Farnsworth are members, of the A.S.T.M. Committee on Die Cast Metals and Alloys, which met February 24 in New York to plan an extensive series of tests of die cast specimens with bases of aluminum and zinc.

J. R. TOWNSEND, F. A. HOYT AND C. L. HIPPENSTEEL visited the Gray Telephone Pay Station Company in Hartford to confer on changes in coin box stations.

D. T. MAY has been appointed a member of the A. I. E. E. Sub-committee on Communication Circuit Protection.

SYSTEMS DEVELOPMENT

R. S. WILBUR, J. W. WOODARD AND D. C. MEYER represented the Laboratories at a conference in Chicago the second week in January, discussing the conversion of the Chicago toll board to the C. L. R. method of operation.

W. L. FILER, F. J. SCUDDER, J. F. TOOMEY, H. W. HEIMBACH AND R. H. MILLER attended the cutover of the new step-by-step dial office and No. 3 toll board at New London, Connecticut, on the evening of January 7.

J. H. BELL, E. P. BANCROFT, E. J. JOHNSON AND J. A. MAHONEY attended a conference held in Montreal January 17 to 21 to discuss plans for the introduction of carrier telegraph equipment on the lines of the Canadian Pacific Railway System.

G. A. HURST made several visits to Boston, to inspect a trial installation of new message registers.

J. G. WALSH has been in Chicago for six weeks beginning January 25 conducting tests on the new No. 701 semi-mechanical P. B. X.

W. C. BEACH has been at McKeesport, Pennsylvania, since January 31 testing cordless "B" dial equipment.

J. A. MAHONEY was in Hawthorne working on lightning suppressor equipment for telegraph systems.

F. VAN VOORHIS visited Pittsburgh, Mount Vernon, Indiana, and Pineville, Kentucky, for studies of noise conditions in central office power plants.

S. F. BUTLER spent several days at Hawthorne discussing the introduction of the new decoder type sender on panel dial equipment.

A. D. KNOWLTON visited Washington, D. C. the beginning of February for an investigation of present equipment preliminary to the proposed installation of dial telephones.

C. E. WHITE has been in Chicago, conducting tests on constant frequency equipment used with the picture transmission apparatus there.

RESEARCH

E. BRUCE sailed on February 11 via the Leviathan for England, where he is going to work in conjunction

with A. G. Jensen on transatlantic radio.

C. H. G. GRAY attended a conference on transmitter testing machines held at Hawthorne by the Committee for the Survey of Apparatus Inspection Methods and Quality, January 23 to 27.

H. A. FREDERICK AND H. A. LARLEE attended a meeting of the American Telephone and Telegraph Repair Committee at Hawthorne February 6 to 11.

HERBERT E. IVES has donated to the Optical Society of America the premium of one thousand dollars, which accompanied the John Scott Medal recently awarded to him for his work in the development of electrical telephotography and television. The money will endow a medal in honor of his father, Frederic Eugene Ives, a pioneer in the application of optical science to color photography and photoengraving.

DR. IVES lectured on "Television" before the Franklin Institute in Philadelphia on February 15, J. G. Knapp assisting him with the apparatus.

R. R. WILLIAMS, J. E. HARRIS, E. E. SCHUMACHER AND C. H. MATHEWSON left for Hawthorne on January 29, where they attended various conferences, particularly on lead covered cable and permalloy dust. On February 2 they visited the smelter and mine of the National Lead Company at St. Louis. From there Mr. Harris and Mr. Mathewson went to Alton to inspect the smelter of the American Smelter and Refining Company, and Mr. Williams and Mr. Schumacher went to Keokuk to visit the plant of the National Lead Company. Mr. Harris, Mr. Schumacher and Mr. Mathewson returned on February 5, while Mr. Williams extended his trip to Gulfport, Mississippi, where he met S. C. Miller, and A. L. Fox of the American Telephone and Telegraph Company. They inspected creosoting plants there and at Texarkana, and discussed a number of problems related to creosoting.

F. F. FARNSWORTH, J. M. FINCH AND H. BOVING, AND E. B. WHEELER AND H. H. GLENN of the Apparatus Development Department, attended a conference on enameled wire held at Hawthorne from February 7 to 14. Mr. Wheeler and Mr. Glenn also discussed questions relating to development of switchboard lamps and to manufacture and testing of toll office cable.

W. G. KNOX AND L. H. CAMPBELL visited the Corona typewriter factory at Groton, New York, inspecting the new Duco finish on Corona typewriters.

R. E. WATERMAN attended the annual meeting of the American Wood Preservation Association held at Montreal January 23 to 26.

A. R. KEMP AND C. L. HIPPENSTEEL visited the Henry L. Scott Company at Providence on January 13 for a discussion of operational details of the rubber compression testing machine which is being built there for the Laboratories. In the same connection, Mr. Hippensteel visited the Scott Company February 14.

ON JANUARY 19, Harvey Fletcher visited the new laboratory of Johns Hopkins Hospital in Baltimore, which has recently been established under the direction of Dr. S. R. Guild to study the anatomy of normal and pathological ears. Mr. Fletcher was also in Washington January 20 and 21, where he gave a lecture on "Instru-

mental Problems of the Deaf" before a sectional meeting of the National Research Council, on Problems of the Deaf.

Inspection Engineering

G. D. Edwards, R. J. Nossaman and D. S. Bender represented the Laboratories at a conference on field engineering work in the territory of the New England Telephone and Telegraph Company, which was held in Boston on January 25.

The Cleveland Field Territory has been divided into two parts. I. W. Whiteside, formerly Local Engineer at Cleveland, has been appointed Field Engineer in the territories of the Michigan Bell Telephone Company and the Indiana Bell Telephone Company, with headquarters at Detroit. G. Garbacz, who had been assisting Mr. Whiteside, is now Field Engineer in the territories of the Ohio Bell Telephone Company and The Cincinnati and Suburban Telephone Company. Mr. Garbacz' headquarters will be in Cleveland.

D. S. Bender, Local Engineer in the territory of The Southern New England Telephone Company, has also been appointed Field Engineer in the territory of the New England Telephone and Telegraph Company, replacing R. J. Nossaman. Mr. Bender's headquarters will be in New York.

C. E. Hooker visited Radio Station WHAM in Rochester on February 7.

W. A. Shewhart visited the Forest Products Laboratory at Madison, Wisconsin, during the week of January 30, to discuss general methods of analyzing engineering data.

W. A. Boyd, H. G. Eddy, R. M. Moody, P. S. Olmstead and E. R. Leroy attended regular Survey Conferences at Hawthorne. W. C. Miller, H. F. Gortheuer and T. Mellors attended similar Conferences at Kearny.

H. W. Newlund, Local Engineer at St. Louis, visited Kansas City and several cities in Texas and Oklahoma during the first part of February, in connection with regular field work in his territory.

P. B. Almquist, Local Engineer at San Francisco, was in Seattle and Portland during January.

Outside Plant Development

B. A. Merrick visited the plant of the P. Wall Manufacturing and Supply Company in Pittsburgh on February 1.

S. C. Miller was in Gulfport, Mississippi, Texarkana, Texas, and St. Louis during February conducting timber preservation studies.

I. C. Shafer was in Boston on February 10 in connection with development problems involving drop wire attachments.

C. S. Gordon visited the plant of the Indiana Steel and Wire Company, Muncie, Indiana, during the early part of February.

On January 23 C. H. Amadon was in Philadelphia attending a meeting of a committee engaged in revising the national safety code for ladders.

Patent

I. MacDonald was in Washington from January 10 to February 8 in connection with the prosecution of application for patent.

Club Notes

THE Spring Dance of the Club will be held in the Grand Ballroom of the Waldorf Astoria on Friday evening, April 27. There will also be provided an hour's entertainment by well-known Broadway stars. Tickets will be one dollar and sixty-five cents and box seats will be two dollars and twenty cents each. Since the demand for box seats at our dances always exceeds the number available, the Committee suggests that those planning box parties order the seats at once. Forty-two boxes will be available.

Bowling

A "free lance" bowling team from Room 910 met the Test Engineers' team of the Western Electric Installation Department Monday night, January 30. The Laboratories team, consisting of T. V. Curley, A. M. Elliott, F. S. Entz, E. D. Johnson and C. White, were in their best form, and won all three games with a high score of 906. High individual average, 200, was made by Elliott. The team wants to arrange games with other capable bowlers in the Bell System.

Golf

Seventy golfers reported to starter L. P. Bartheld at the Vander-Built-In Golf Course on Wednesday evening, January 25, for the second indoor tournament of the season.

Thirty-six holes of medal play were required to determine who would qualify for the final match play. T. C. Rice carried off the prize for low medal score in Group 1 and F. D. Smith won a similar prize in Group 2. Each prize was a half-dozen golf balls donated by Alex. Taylor & Company.

The gallery had an opportunity to see some fine golf in the finals. One match that provided suspense till the finish was that in Class A, Group 1, in which T. C. Rice defeated J. G. Roberts only after the eighteenth hole had been played. H. Wood gained a three and one victory over W. Burger in Class A, Group 2. In Group 1 of Class B, G. H. Heydt won from A. A. Reading, and in Group 2 of the same class, J. Hillier defeated F. S. Entz. In the first group of Class C, E. G. Paterson was defeated by W. F. Johnson, while in the second group J. V. Moran defeated G. Kellogg. In Class D, W. Smith was the victor over O. D. M. Guthe in the first group, and in Group 2, H. K. Farrar won from D. M. Terry.

The next indoor tournament will be held Tuesday evening, March 27.

Glee Club

The Glee Club for Men and Women was reorganized on January 19 and held its first rehearsal in the Auditorium on Monday evening, January 23. This group is being trained by Mr. L. K. Le Jeune, a paid director who has been engaged to coach the Glee Club for a period



Club basketball team. Standing: Christ (Systems), Waldron (Apparatus), Hanson (Shop), Hiscock (Commercial); seated: Hasior (Systems), Maurer (Research), Gittenberger (Systems), Steinmetz (Commercial), O'Neill (Systems)

of fifteen weeks. Each Monday evening at 5:10 Mr. Le Jeune will be more than pleased to give newcomers a welcome and an opportunity to sing.

WOMEN'S ACTIVITIES

Dancing

The members of our dancing class are still reporting at Louis Vecchio's studio on Monday evenings, their versatile talents ranging from the leisurely tango and stately waltz to the intricacies of soft-shoe and tap dancing.

Swimming

Swimming is largely a matter of form, as Miss K. Spranger's pupils are fast finding out. Miss Spranger is substituting for Miss Steil, who was recently the victim of an unfortunate accident. The swimmers are rapidly learning the six- and eight-beat crawl, and several of the more intrepid are now performing creditable jack-knife and swan dives. The class meets at the Carroll Club, each Monday at 7:00 and Wednesday at 5:30.

Basketball

The outside games of the Women's Basketball Team are still progressing. During January and February seven games were played. With two more to be played in March, the schedule will be complete, and a final report will be ready. The season's records indicate that if such able players as Natalie Skinner, Lillian Kaempffe and Mandy Reinbold continue their high scoring, we shall have an undefeated season. The last two games, which should prove the best, are: Thursday, March 1, at five-thirty, with the Federal Reserve Bank, at 44 Maiden Lane; and Friday, March 16, at eight o'clock with the Hempstead Varsity Alumnae



Women's basketball team. Seated: Mary Zwarick, Harriet Newman, Ann Barioni, Alice Pease, Lillian Kaempffe; standing: Marion Grimm, Margaret Brisbane, Natalie Skinner, C. Gittenberger—coach, Marie Boman—captain, Jean Hassett, Mandy Reinbold

team, which two years ago played the champion team from Ohio and won the National High School Championship.

Bowling

There is a new activity for women in the Club—bowling. This new interest gives indications of creating the same enthusiasm among the women as it has done for the past few years among the men. The management of this activity will be patterned on the Men's Bowling League, so that by fall the Women's Bowling League will be fully organized. All girls interested in bowling and who have not already sent in their names are urged to communicate with Miss A. E. Hamilton at once.

Women's Bridge Tournament

A source of satisfaction to the women bridge players was the evening of Tuesday, February 7, when twenty players from the Laboratories played an equal number from the General Headquarters of the Western Electric Company. After three hours of intense playing, and astute bidding, our team won by a total score of plus 4,326. Our players were:

Catherine Maull
Katherine Munn
Mildred Theubel
Thelma Taylor
Elizabeth Priztkow
Marion Stein
Marguerite Johnston
Helen Wilson
Allegra Hamilton
Marion Cater

Eleanor Barton
Gertrude Beidel
May Murtagh
May Lynch
Virginia Crim
Ellen Kerney
Evelyn Brisbane
Margaret Packer
Hazel Mayhew
Martha Kopf

BELL LABORATORIES RECORD

SIGNAL SHAPING
By A. M. Curtis

OUR INSURANCE PLAN
By J. E. Moravec

THE LOCAL CIRCUIT LABORATORY
By J. L. Dow

APRIL 1928 VOL. 6 No. 2

Bell Laboratories
Record

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"Signal Shaping" for Submarine Cables

By A. M. CURTIS
Research Department

THE problem of signal shaping, more familiarly known as attenuation equalization, is one of the oldest in electrical engineering. In 1854 certain pioneers were discussing the possibility of a transatlantic submarine cable and there was a general opinion that the current would all leak out before it reached the receiver. Partly to settle this matter, E. O. W. Whitehouse and Professor S. F. B. Morse conducted some experiments in which signals were transmitted over 2,000 miles of British telegraph lines looped to form a continuous circuit. In these experiments it was found necessary to use a type of transmission in which "signal shaping" was accomplished by having each positive signal followed by a weaker negative signal and thus partly neutralizing the effect of the capacity of the line.

In 1858, following the laying of the first Atlantic cable, attempts were made to increase its speed of about ten letters per minute by sending through a huge induction coil. This was a step in the right direction, but unfortunately the coil did not match the impedance of its circuits very well and the excessive voltage applied to the cable ruined it in a few days. These experiments now seem childish in view of our present knowledge, but it should be remembered that this all took place even before a system of electrical units had been devised, when Ohm's law was still a novelty and the very existence of inductance, as we understand it, was disputed. Before the cable failed it was established that the speed of transmission, using a mirror galvanometer as a receiver, was fifty per cent higher than that when ordinary telegraph instruments were used. The fact appears to have been overlooked that the galvanometer constituted a mechanical resonant system which when properly adjusted improved the shape of the signals.

In 1866 two successful Atlantic cables were completed. In them, use of a series condenser as an additional shaping element with the galvanometer permitted the very satisfactory speed of seventy-five letters per min-

ute to be reached and allowed the rate per word to be reduced to one pound sterling.

In 1867 Kelvin's siphon recorder was introduced and still another shaping element, a condenser in series with the sending end of the cable, was added. Development of signal shaping methods appears to have rested here for about thirty years although the introduction of duplex operation and automatic transmission still further increased the speed to about two hundred letters per minute in each direction.

About 1898 shunt inductance elements were added to the shaping networks which then began to resemble our simpler attenuation equalizers. The improved shaping and later the use of mechanical amplifiers permitted the speed on the newer North Atlantic cables to be increased to 250 letters per minute in each direction, and here it stayed until the advent of permalloy loaded cables.

A simplex speed of 2,500 letters per minute in cable code with recorded reception has been demonstrated on the latest permalloy loaded cable laid between Newfoundland and England. At this speed vacuum tube amplifiers and complicated shaping networks are required. As the cable attenuates the higher frequencies contained in the signal much more than the lower ones, the sending networks and the receiving apparatus are designed to reverse the process and equalize the attenuation of the cable. In the final result, the overall attenuation of the system is practically constant between about one-half and fifty-five cycles per second but then increases rather rapidly until the voltage received at 111 cycles is about one-twelfth that at fifty-five cycles. The lower frequencies, which would otherwise be transmitted in excessive amounts, are penalized by series condensers, shunt inductances, and other devices which reduce the sensitivity of the receiving amplifier to the lower frequencies while making it more sensitive to the higher frequencies.

As very few engineers realize how enormous is the improvement in cable signals produced by the modern shaping systems, it will be of interest to

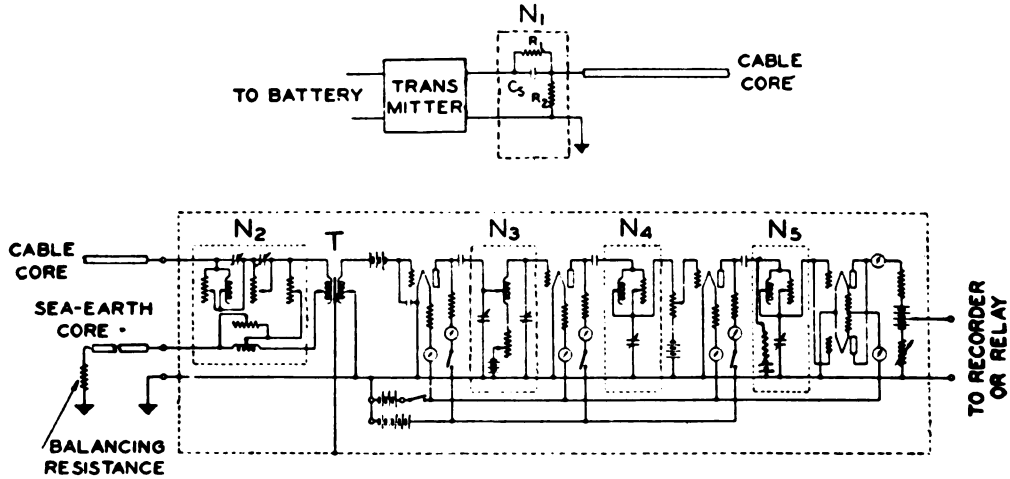


Figure One

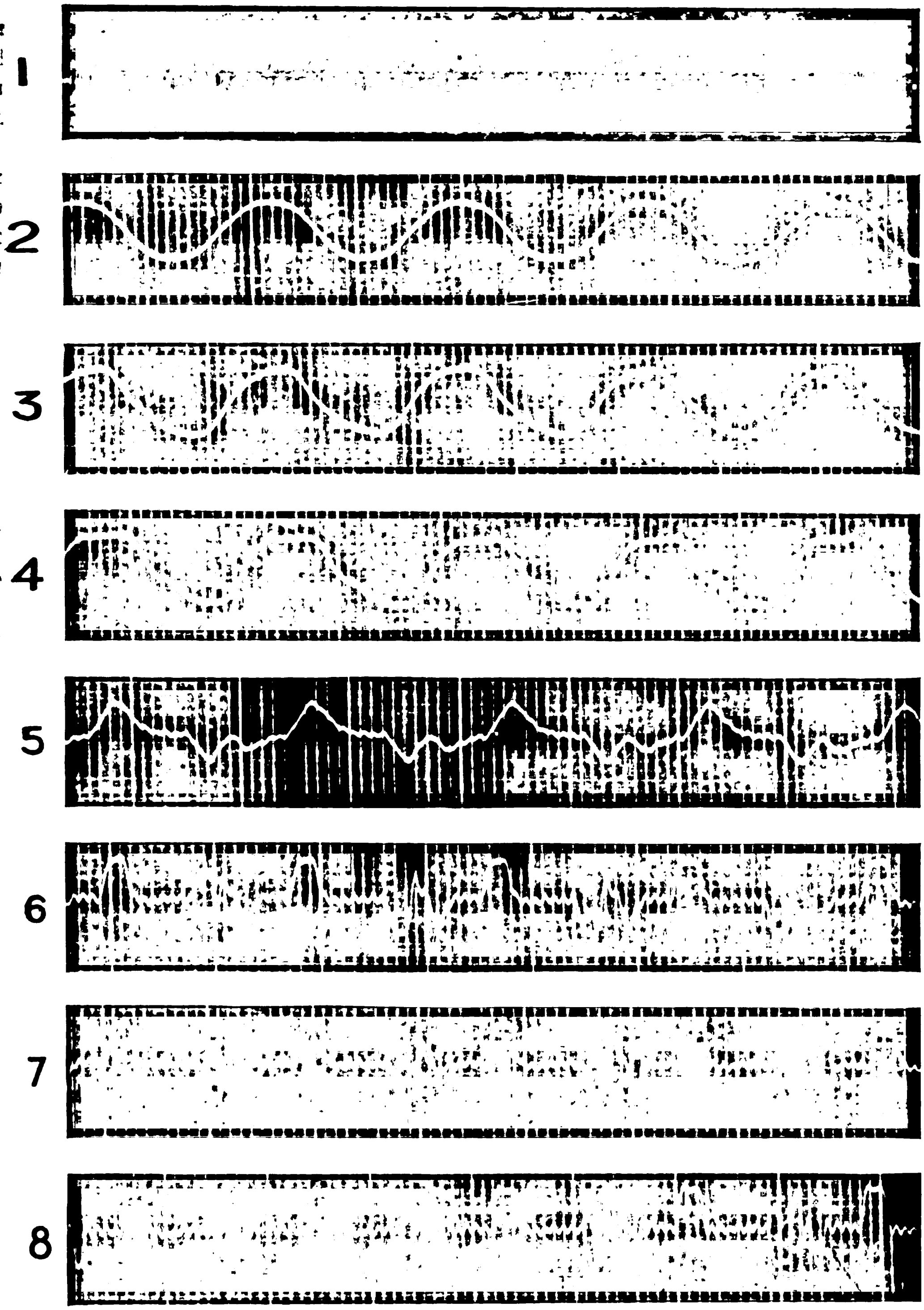


Figure Two

demonstrate this by a series of oscillograms made in the laboratory on an artificial line representing the cable mentioned above. The speed at which these signals were transmitted was 2,640 letters per minute. The shaping of the signals was done with the intention that the highest reversal frequency (111 cycles) would not be received from the cable but supplied by a synchronous vibrating relay which forms part of the receiving apparatus.* Oscillograms of the transmitted signals and the corresponding received signals were taken with the string oscillograph. The time lines on the oscillograms are one hundredth of a second apart. These were omitted in the case of the transmitted signals as they would have obscured the trace considerably. The cable and amplifier system used in these experiments is shown in Figure 1. Since the strong lower frequencies of the signal are suppressed in favor of the much weaker high frequencies, it is of course necessary to increase the gain of the amplifier in order to keep the received signal at a value which will operate the receiving device, which in this case is the oscillograph.

As the first step in the experiment all the shaping networks were removed from the sending and receiving terminals of the artificial line and also from the amplifier. Oscillogram No. 1 shows the voltage applied to the cable by the transmitter. It consists of a group of forty pulses forming eight printing telegraph code characters repeated continuously.

Oscillogram No. 2 shows what is received without any shaping, a slightly distorted sine wave of about five and a half cycles frequency. The amplifier gain required for this signal will be called unity and the gains corresponding to other stages in the shaping will be expressed very approximately as multiples of this initial gain merely to give a rough idea of how much of the signal must be discarded before it is intelligible.

Oscillogram No. 3 shows what happened when the sending end network was added. In this particular experiment the latter was adjusted so that its effect was not very marked, but it will be noted that the wave which was originally smooth is now quite rough and distinctly unsymmetrical. The amplifier gain was twice the initial gain.

No. 4 shows the effect of adding the shunted receiving condenser of the receiving network, N2. The gain is eight times the initial gain. A distinct inflection is now observable in the wave and it is decidedly flat on top.

No. 5 shows the effect of adding the entire receiving end network, N2, the gain being increased to seventy-five. A marked increase in definition is noted and distinct signs of the 111 cycle component appear.

No. 6 shows the effect of adding the first amplifier interstage network, N3, the gain being increased to 150. A sort of family resemblance between the received signal and the transmitted voltage can now be detected.

No. 7 and No. 8 show the increase in definition caused by adding the amplifier networks N4 and N5, respectively, the gain being approximately the same as for No. 6.

If No. 8 is now compared with No. 1, every characteristic of the transmitted signal will be recognized although the exactness of the repro-

* *See A. A. Clokey, Bell System Technical Journal, July, 1927, page 402.*

duction varies. The string of six pulses is reasonably like that transmitted. The double and triple signals are rounded off to resemble sine waves and the groups of single pulse reversals, while perfectly recognizable, are too small in proportion to the rest of the signal to be used to operate a receiving relay satisfactorily. The shaping process might have been continued until the 111 cycle component had been brought to an amplitude equal to that of the other signal components, although it could never be made an exact duplicate of the transmitted wave, as this would require the transmission of frequencies much higher than any cable will pass. It is, however, possible to apply the signal of No. 8 to the synchronous vibrating relay system and restore it to exactly the wave form transmitted. This is the plan followed in our cable printing telegraph system, as it permits a considerably higher speed of operation than is possible if the highest frequency is received in full amplitude from the cable.

Bell System Plant Additions

Additions to plant and telephone equipment of the Bell System during 1928 *call for an expenditure of* $420,000,000, *a sum almost half as great as the national debt at the time the United States entered the war, and considerably larger than the cost of constructing the Panama Canal. The magnitude of the operations is indicated by the facts that* 950,000 *poles are to be used, duct is to be placed for* 3600 *miles of underground cable, and circuits with a length of* 3,340,000 *miles are to be installed in aerial and underground cable. Prominent among the year's accomplishments will be completion of the second cable route between New York and Chicago.*

Platinum Alloys for Vacuum Tube Filaments

By J. E. HARRIS
Research Department

THE filaments of vacuum tubes used by the Bell System consist of ribbons of carefully prepared platinum alloy coated with the oxides of barium and strontium to give a higher electron emission. It is often asked why platinum is used instead of some less expensive metal such as tungsten, molybdenum, chromium, or iron. The answer is that the material of the filament core must be of such a nature that either there will be no chemical reaction between it and the barium and strontium oxides during the coating process, or in case some such a reaction is unavoidable that it will not destroy the thermionic activity of the coating.



H. L. J. Siedentop watching "melt" of platinum in high frequency induction furnace

This requirement rules out the base metals mentioned above. Tungsten, for example, when heated in air in contact with barium and strontium oxides unites with them and destroys their property of emitting electrons copiously at a low temperature. It is true that platinum may form compounds with barium and strontium oxides but these, unlike those formed with tungsten, are of such a nature that they are destroyed when heated in vacuo in the process of evacuating the tubes, the barium and strontium oxides being reformed on the surface of the filament.

The filament alloy must consist of metals which may be purified to a high degree since it is known that the presence of small amounts of impurities in the filament may have an effect on the thermionic activity out of all proportion to the amount of impurities present. This prevents the use of certain metals of the platinum group, such as iridium, ruthenium, osmium, and rhodium, which can be purified only with the greatest difficulty.

The alloys of platinum which we need are not commercially produced and this fact together with the need for exceedingly pure materials has made it necessary to purify the metals and to produce the filament cores in the Laboratories. For this purpose, the best grades of commercial materials are purchased, dissolved in acids, and carefully purified, after



Fusing a platinum rod with oxyhydrogen torch to remove bubbles and air pockets

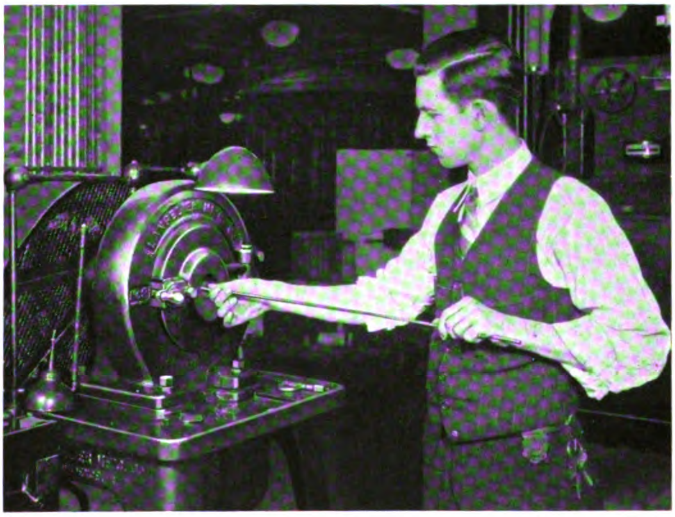
which they are reduced again to the metallic state.

The platinum comes to us in the form of platinum sponge: a gray, amorphous, powdery material not at all similar in appearance to the platinum we see in the form of jewelry. This platinum is from 98 to 99 per cent pure, the impurities consisting for the most part of rhodium, iridium, and palladium, metals which are closely related in their properties to platinum and which are separated from it with considerable difficulty. These are carefully removed by methods which we have worked out in these Laboratories so that the platinum when ready to use has a purity of at least 99.98%. The purity of the metal is readily determined by a thermoelectric test, the thermal e.m.f. developed between a sample of the platinum being tested and another sample of known purity giving a direct measure of the impurities present.

In connection with this purification frequent use is made of the spectroscope by means of which it is possible to determine what impurities are present and roughly to what exent. This information is often of great assistance in guiding the work of purification.

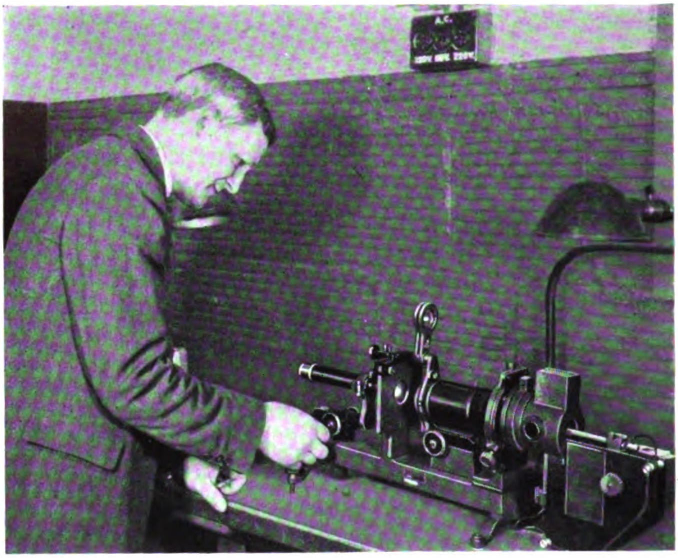
The platinum and the alloying metals are finally obtained in the form of sponge which is pressed together into pellets and melted in an induction furnace of a type similar to that recently described in an article in the RECORD by J. H. White. For melting the alloy a temperature of approximately 1750° C. (3400° F.) is required.

After being melted and cast, the metal is rolled and swaged until a



C. F. Larkins swaging platinum rod as the first step in size reduction

rod ¼″ in diameter and three or four feet long is obtained. At this stage, it is necessary to go over the bar carefully with an oxyhydrogen torch to work out the gas pockets and bubbles embedded in the metal. In this process all the metal in the rod is fused slightly a little at a time. If this is not done the gas pockets are drawn out with the metal in the working process which causes the wire, when the smaller sizes are reached, to break into many pieces and sometimes makes it impossible to draw the wire at all. When the rod has been sufficiently treated in this fashion to give a perfectly sound bar it is further swaged and drawn into wire of the required size and finally rolled to ribbon ready for shipment to the tube shop.



The projector for measuring the width of platinum alloy ribbon is shown in operation by H. T. Reeve

The final diameters of the wires from which the ribbon is to be rolled vary from one to thirteen thousandths of an inch, depending on the type of tube for which they are intended.

The filament from the one thousandth inch wire is used in a tube having a filament current of six hundredths of an ampere and that from the thirteen thousandth inch wire in a tube having a three ampere filament current. A conception of the fineness of the smallest size wire may be gained from the fact that, although the alloy is twenty times as heavy as water, it requires more than a mile and three-quarters of the wire to weigh an ounce.

The final step in the production of filament core is that of inspection. In the production of filament it is necessary, in order to insure the proper electrical characteristics for the tubes, to work to such close dimensions that even the most accurate of micrometers is not exact enough to measure the dimensions within the limits desired. For this reason the cross-section of the wire is determined by weighing samples a meter long. The width of the ribbon in the types of filament where the greatest accuracy is required is determined by projecting an image magnified a thousand times on a screen properly calibrated so that it is possible to tell by a glance at the image whether the ribbon falls within the required limits.

Improvements in the core and in the coating and pumping processes have made it possible within recent years to increase the life of repeater tubes many fold, with large resultant savings to the operating companies and improvement in service.

Our Insurance Plan

By J. F. MORAVEC
Commercial Manager and General Auditor

LIFE insurance, as I view it, is a real asset to the present and future estate of any individual. It affords immediate protection to dependents in the hour of need and additionally combines with it, throughout the life of the policy, sound investment. I believe that most of us are apt to treat this matter of life insurance too lightly.

Recently we have each received a copy of the booklet concerning the Insurance Plan as adopted by the Laboratories, containing the terms and conditions under which insurance may be obtained. Perhaps some of us for one reason or another neglected to read this booklet. Others, perhaps, glanced through it superficially without much interest and have only a hazy idea of what it is all about. To all I would say, "Read it and read it carefully," for without question this Plan offers real advantages which many of us may not appreciate. The necessity for life insurance is very generally admitted but only too often the provision for such protection is delayed so long that when disaster overtakes us we find ourselves without adequate insurance and in some cases no insurance at all. Our intentions were good, but have you heard of anyone who protected his family or dependents with good intentions only? Delay is costly and one sure thing about insurance is that the price increases the longer we wait to do what in most instances we are eventually going to do.

The first question which, I take it, comes to the minds of most of us concerning the Plan is: "How much cheaper can I purchase protection under the new arrangement?" And when told that there is no premium saving under the Plan except for those who are engaged in so-called "hazardous occupations," we are quite likely to decide once and for all that the Plan offers little or no reason for us to participate. If it had not been for the fact that I, as a member of the Committee which considered the advisability of adopting the payroll deduction insurance idea in the Laboratories, was afforded the opportunity to investigate the matter from all angles, I too might have decided similarly. As it was, I studied the Plan fully, considering it in the light of past experience and in its relation to the other employee plans of the Laboratories, and came to the conclusion that it offers a real service to all of us who desire to participate. Accordingly, it seems to me that the salient features of the Plan are worthy of fuller discussion than can be given in the Plan Booklet.

First there is the payroll deduction feature. Experience has taught all of us that it is better to save first and spend afterward than to spend first and then save what there is left. The recognition of this fact underlies the

Savings and Stock Plans and is now incorporated in the Insurance Plan as well. To achieve financial independence, one of the most practical ways for most of us is to fix our saving at a certain point by arranging that we receive that portion of our income that we plan to spend and have the rest automatically accumulated for us in the form of savings, stock or insurance. This arrangement is accomplished through the payroll deduction scheme.

Even for those who can readily provide in advance for their financial obligations the payment of life insurance premiums through salary deductions may prove an advantage in that it relieves them of the necessity of paying premiums personally to the insurance company. This is particularly true because arrangements have been completed with the insurance company since the inauguration of the Plan which make it possible to derive the advantage of the lower premium rate for *annual* payments and at the same time pay premiums through deductions from pay. This may be accomplished in one of two ways: (1) You may, at the time of taking out your policy, pay the first annual premium in full to the insurance company. Then you may authorize deductions from pay to be held by the insurance company and used to meet, annually, succeeding years' premiums when they fall due. (2) You may, at the time of taking out your policy, authorize deductions from pay in such amounts as will meet payments on the current year's premium and will in addition accumulate in advance funds sufficient to pay in full the succeeding year's premium when it becomes due. This is in effect a double deduction, partly for current year's premium requirements and partly to enable you in the succeeding year to operate your insurance payments on the basis described under option 1 above. Both of these options utilize the deduction scheme as applied to insurance very much as you might use the Savings Plan to accumulate funds to meet your premiums for the succeeding year. In this connection the insurance company agrees to credit you with interest at the prevailing rate (which at the present time is 4¾%) on all amounts accumulated in advance until the time these amounts are applied in payment of annual premiums.

I feel, furthermore, that the payroll deduction feature may appeal to those who hold policies of the Equitable Life Assurance Society taken out prior to the inauguration of the Plan, since that company has extended to them the privilege of authorizing payroll deductions for the payment of premiums on such insurance, regardless of whether or not they take out new insurance under the Plan.

The omission of the customary medical examination in cases of applicants between the ages of 15 and 55 inclusive for amounts up to a total of $10,000 for any type of policy except Term is another feature of the Plan. Of course, the insurance company reserves the right to call for an examination when the physical condition of any employee would seem to indicate that this is necessary; but as most of us in the Laboratories are good risks from a health standpoint, this right will probably not be exercised very frequently.

In all of this it is well to keep in mind that under the payroll deduction plan your insurance is not dependent upon your continued employ-

ment with the Laboratories. You take out your insurance as an individual but your premiums are automatically cared for through payroll deductions. If at any time you sever your relations with the Laboratories, the protection you have bought stays with you. The only change would be that premiums on a quarterly, semi-annual or annual basis would be paid direct to the insurance company by you. The essential factor — protection — would not be affected in any way. Furthermore, when you take out insurance under the Plan, you have all the rights and privileges of a policy holder not under the Plan. As a matter of fact you are in a preferred position by reason of the advantages which I have mentioned.

Finally, in the Equitable Life Assurance Society of the United States, the Company selected to operate under the Plan, we have one of the strongest, oldest and most progressive institutions in the insurance field.

The selection of the proper life insurance is frequently an intricate matter and there is now available to all members of the Laboratories the service of an insurance expert, Mr. L. H. Bunting, who is the local representative of the Equitable, and who is now located in Room 144. He is ready to extend to anyone who may call upon him assistance in changing provisions of payments or beneficiary, and in all other life insurance matters, whether for policies of the Equitable or of other companies. The service, in short, will be that generally offered to only the largest policyholders of a life insurance company. Those who desire Mr. Bunting's advice may feel free to discuss their insurance matters with him. He may be reached by telephone on Ext. 264.

In conclusion may I emphasize that life insurance is something which all of us should consider seriously and which most of us should make a part of our financial scheme, particularly if we have others dependent upon us.

Carrier Telegraph in Canada

By J. C. BURKHOLDER*

SPANNING the entire continent through the territory of our northern neighbor lies the Canadian National Railways System. A journey over its lines discloses scenery that warrants the almost unlimited use of superlatives. Jasper National Park, the largest national playground in the world, occupies but one small section of an almost continuous panorama of natural beauty and grandeur. Although its twenty-two thousand miles of track thread many large cities, much of its right-of-way is through a lonely country which the rapid growth of Canada has not yet compassed. From some of its station platforms bears are not uncommon sights and for the entertainment of the few inhabitants the howling of wolves is a frequent accompaniment of the northern lights which so frequently illumine the long winter nights, adding beauty to the scenery but severely hampering the operation of the telegraphs.

One of the major departments of this railroad system is the Canadian National Telegraphs whose lines connect with those of the Western Union Telegraph Company in this country. Canada has been growing rapidly and it was realized some time ago that the telegraph facilities had become inadequate and that extensive additions were necessary. One and a half million dollars was the estimated cost of providing the required channels by adding new wire circuits. The same facilities could be procured, however, by the use of multiplex carrier circuits at an estimated cost of only half a million. The proper step to take was obvious.

Orders were placed with the Northern Electric Company for a complete carrier system consisting of five terminal stations, twelve repeater stations, and a repeatered telephone circuit between Montreal and Winnipeg by way of Toronto, all to operate on the same pair of wires. For this work the system was divided into four sections: Montreal to Toronto, Toronto to Winnipeg, Winnipeg to Saskatoon, and Saskatoon to Vancouver.

The installation involved no small undertaking. Carrier current telegraphy was entirely new to Canada and there was therefore no one familiar with the details of the system. In addition the distances spanned are enormous; the link from Toronto to Winnipeg—over thirteen hundred miles and requiring seven repeater stations—is the longest in existence. Compared to carrier circuits in this country, the actual electrical length of this link is much greater than that indicated by the number of miles because the wire used has double the resistance of that ordinarily used by the American Telephone and Telegraph Company.

**Mr. Burkholder, formerly a member of the Systems Development Department, was the representative of the Laboratories in the engineering and installation of the system he describes. He has since become Chief Engineer of the Canadian National Telegraphs.*

Canada in some respects is particularly suitable for carrier installations. The fact that the distances are great between the large cities and that there are very few towns of any size intervening makes a carrier system very attractive economically. Of even greater importance, however, is the freedom from interruption that the carrier will bring. The effect of the aurora on grounded telegraph systems over the territory covered by the Canadian National Telegraphs is often calamitous. At times service is impaired for days at a time. The carrier, bringing almost complete immunity from auroral disturbances, due to its being an ungrounded system operating through transformers, will be worth much more to Canadian industry than the million saved by its original installation.

Having been asked by Northern Electric for technical advice and assistance, the Laboratories pointed out that the operation of paralleling telegraph circuits at 240 volts might seriously affect the carrier system. It was decided, therefore, to complete first a portable single carrier channel which could be used as a test circuit to determine what changes in the line would be necessary for the successful operation of the complete transcontinental carrier telegraph system.

While making tests in the fall of 1926, electrical disturbances were reported east and west of Capreol which lies just north of the western end of Georgian Bay. All this territory north of Lakes Huron and Superior is wild and very sparsely settled. Almost the entire population is in townships of two or three hundred people at the railroad division points. No roads exist; the railroad and its telegraph lines are the only links connecting these remote centers with the rest of the country. As the line had been reported in good condition and further as line inspection and maintenance in such a country is difficult, elaborate tests were made to locate the trouble and to discover its cause. While the tests were under way, the trouble disappeared, but not for long.

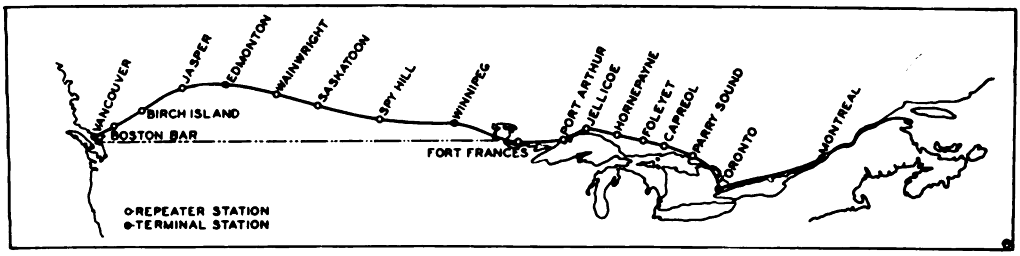


Fig. 1—Map of Canadian National Railway System showing carrier terminal and repeater stations

During 1927 installation of the equipment went steadily along. Buildings had to be designed and erected to house the equipment at several of the repeater stations. The accompanying photograph at Foleyet shows a typical repeater station in the foreground, built on to the old station with the higher gable just behind it. When testing was resumed on the Toronto-Winnipeg section in the late



Fig. 2—Repeater Station at Foleyet; (3) gas car ready for inspection trip; (4) tangle of brush and wire; (5) the Yale Tunnel

summer of 1927 the same peculiar disturbances that had caused so much trouble the year before reappeared.

In view of the elusive nature of the disturbances, which indicated slack wires as a possible cause, it seemed wise to make a personal inspection of the entire line west of Toronto. For this purpose the small gas car shown in Figure 3 was used. Linemen were taken along to repair bad sections as they were found. In general, conditions were far from being as good as had been at first reported. In some places the brush had grown up into the sagging wires, as is shown in Figure 4. At night tests were made both ways from that night's stopping place. As the inspection party proceeded the interference became less and less till when Foleyet was reached the trouble had almost entirely disappeared. The line while satisfactory for ordinary direct current telegraphy was evidently not in sufficiently good condition for carrier circuits.

Still the line was noisy in some sections so that tests were continued and further line inspections made, in the course of which the poles between transpositions were counted. Where irregularities were found additional transpositions were inserted. In one place where a 110,000 volt power line paralleled the telegraph circuit for about two miles it was necessary to put transpositions at every pole.

Day by day and night by night the repairing and testing went on. Much

of the country is rough, requiring considerable detours from the track as may be understood by reference to Figure 5. Also the work was not without its hazards. Except for the section from Montreal to Toronto the system is single track and constant watch had to be kept for trains. At one time we came suddenly upon a freight train and had just time to jump as the gas car rolled into the rear end of the train. On another occasion while we were traveling along at about forty-five miles an hour with our eyes fixed on the telegraph line the car ran into a derailing switch. Smashed equipment, an overturned car, and rather bruised observers were the result.

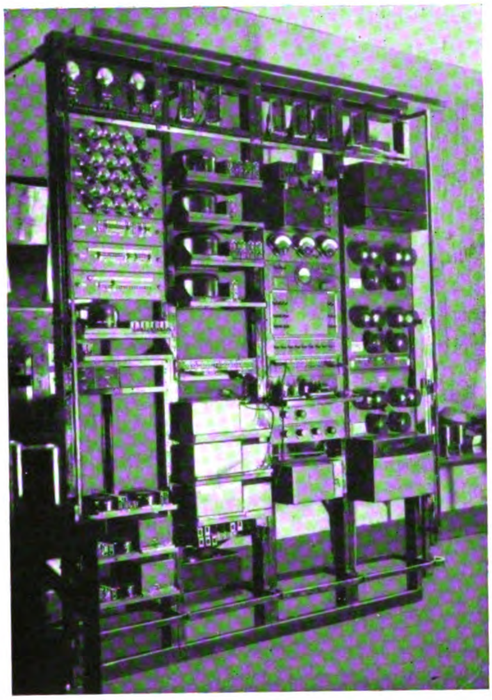


Fig. 6—Carrier panels in typical repeater station

The Toronto-Montreal section was opened to commercial service on April 26, 1927. On this day W. G. Barber, General Manager of Telegraphs, sent the following telegram from Toronto to Vice-President Robb in Montreal: "The carrier telegraph installation Montreal-Toronto has been completed and is working successfully. This message goes to you as the first message over a four channel multiplex operating at fifty words per minute on one of the telegraph carrier channels. This is the first time in telegraph history that a telegraph system has operated successfully carrying both multiplex printer and Morse telegraph messages over its various channels at such high speed."

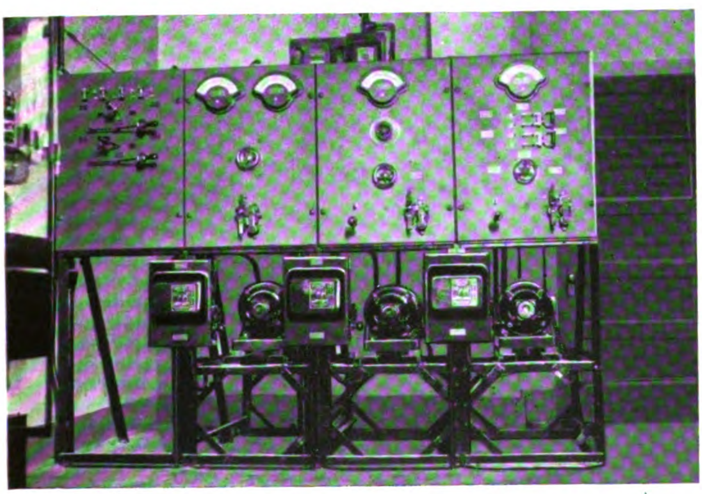


Fig. 7—Power plant for repeater station

A little over six months after this, on November ninth, the section from Toronto to Winnipeg was opened with a public demonstration at each terminal. This marked the completion of more than half of the total distance of over

thirty-two hundred miles. While only six carrier channels had been planned originally for this section, traffic had grown to such extent that it was necessary to take equipment built for one of the western sections to increase the Toronto-Winnipeg sections from the six carrier channels originally planned to ten. In addition it had been decided to install an additional terminal station at Edmonton and to relocate the repeater stations originally planned for these western sections.

With this considerable accomplishment behind them the Canadian National Telegraphs is going on with the installation of the remaining sections which will complete its continental span from Montreal to Vancouver and insure that during the long winter months the aurora will no longer be a menace to telegraphy.

A Treatise on Probability

"Probability and Its Engineering Uses," by Thornton C. Fry, has just been published by D. Van Nostrand Company as part of its series of books by the staff of Bell Laboratories. An outgrowth of notes for the course given here and at a subsequent course of lectures at Massachusetts Institute of Technology, the book deals with many aspects of the interpretation of engineering and other data.

Considerations of probability have been used so effectively in correlating telephone facilities to traffic, necessarily irregular in flow, that the formulae and principles involved are of especial interest. More recently the same procedure has been applied to determine the stocks of materials and supplies needed at Hawthorne and Kearny, and to provide a rational means of inspection and control of the quality of manufactured products there.

The Local Circuit Development Laboratory

By J. L. DOW
Systems Development Department

IN the development of circuits for local service both a design and a laboratory group participate. Although not taking a direct part in their creation the laboratory yet shares responsibility equally with the design group for the circuits which proceed to the field. Its function is to check all arrangements which may be proposed and issued; its responsibility is to see that not the smallest item is overlooked which might lead to possible failure. To insure success in every way humanly possible the laboratory group must therefore verify in actual operation all circuits proposed by the design group.

In carrying out this function each detail of every scheme is given careful scrutiny, a work requiring a staff of 128 trained engineers and some 46 assistants. The department is subdivided into groups, each containing specialists in one particular field. Relays, panel-type equipment, manual equipment, step-by-step equipment, special development problems, and field study and installation requirements, has each its own group of engineers who not only carefully analyze but test each new circuit that falls within its function.

Last year over eight hundred new circuits were issued and over two thousand reissued. Some new circuits involve such well known principles and schemes that they may be approved without test but most of them



F. L. Cox examining local cable form of a cordless tandem circuit being wired by W. S. Hane and C. E. Blumenaur

must be carefully tested before they can be approved. To accomplish this each must be set up on benches in the laboratory; adjusted under the most adverse conditions that it may ever meet; and tested, not only by itself, but in conjunction with every other circuit to which it may be connected at any time. When the circuit with its associated equipment occupies too much space to be mounted on benches, as would be the case with panel type senders for instance, it is set up on standard telephone frames in the machine switching section of the laboratory.

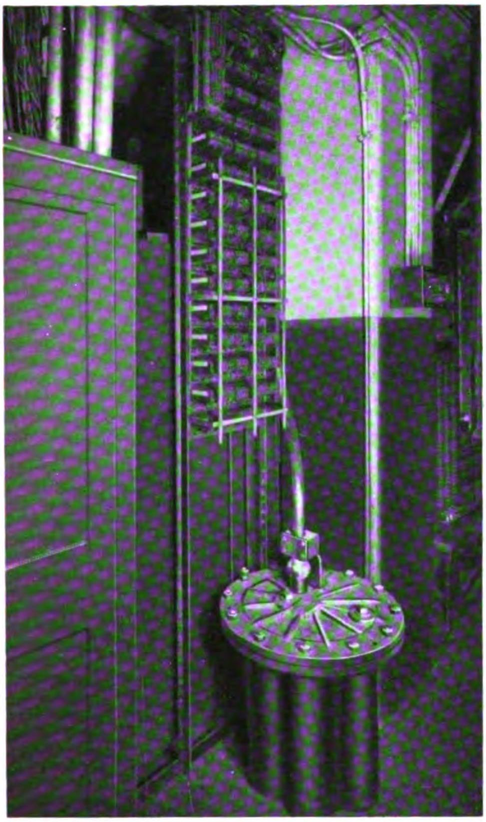
Making the local cable forms for these tests and cutting-in the apparatus on the frames or benches keeps a group of twenty-six men busy. Each group of circuits is delivered as though it were to be placed in a central office for the service of the subscriber.

Probably the most used single piece of apparatus in the laboratories — as in the telephone plant in general — is the relay. Twelve thousand of them were used in tests last year by the Circuit Development Laboratory. A large number were special or newly-designed relays which were made in the Model Shop solely for the purpose of being tested in the circuits under investigation. Each must be tested and adjusted both electrically and mechanically before it is placed on the frame and sometimes readjusted later during the testing of the circuit. Fifteen thousand relay adjustments were made last year. In many cases they are delicate and demand skill and care to secure their satisfactory accomplishment.



A. Bregartner adjusting a series of "E" type relays

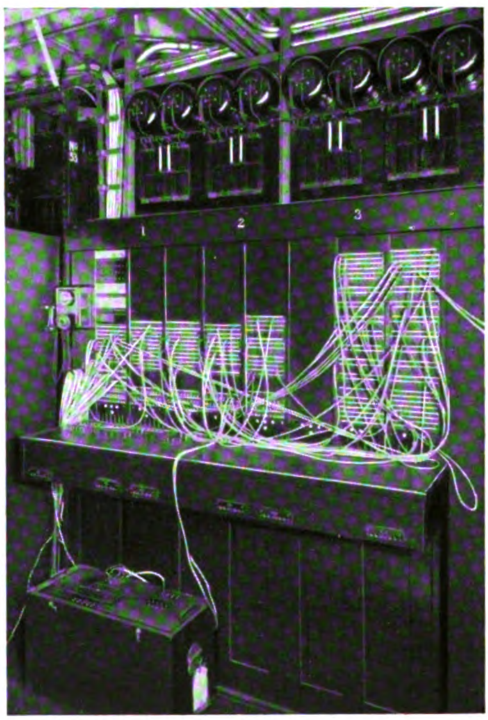
Many interesting types of equipment are used by the engineers in the course of their work. Besides the usual instruments for measuring voltages, currents, and power of all magnitudes there are many special types of apparatus, among which is the pulse varying machine which was made necessary by the advent of dial systems and the resulting studies involving pulsing. This device, of which there are four in the labo-



Loading coil pot with condensers and resistances used in making up the 40 sections of loaded No. 19 gauge cable. These sections are terminated in jacks in the left hand end of the patching section shown in the adjoining column

ratory, provides means of sending a group of short electrical impulses such as are produced when the subscriber dials. These machines will produce either a continuous chain of pulses of any frequency from five to thirty per second or groups of any number of pulses separated by open periods. The duration of both the pulses and the open periods is adjustable. This makes it possible to determine the type of pulsing necessary to accomplish any particular result and also to determine the performance of relays under different pulsing conditions and lengths of circuit.

To determine limiting distances, or length of loop, for different circuit functions, artificial lines are provided: electrical networks simulating very closely the characteristics of the various types of cable and open wire lines. These are built up in unit sections so that any desired length of line may be readily selected. Particularly interesting is the artificial duplication of forty sections, each equivalent to 1.66 miles of loaded nineteen gauge cable. This is built up of condensers, resist-



Main patching section which gives each engineer access to the common equipment of the laboratory

ances, and loading coils in proper combinations and the sections terminate in jacks mounted in the laboratory patching section.

This patching section enables any engineer to have access to all the artificial lines described above and to all other circuits in the laboratory. Trunks running to various parts of the laboratory and to other laboratories in the building terminate in jacks mounted in the patching sections and the desired connections are made by plug-terminated cords. Each new circuit must be tested with the circuits with which it is to be associated so it is necessary to provide and maintain all the equipment which is found in standard central offices, not only manual but panel and step-by-step, as well as equipment for all forms of private branch exchanges. All these circuits terminate on a distributing frame and most of them are connected to the patching section.

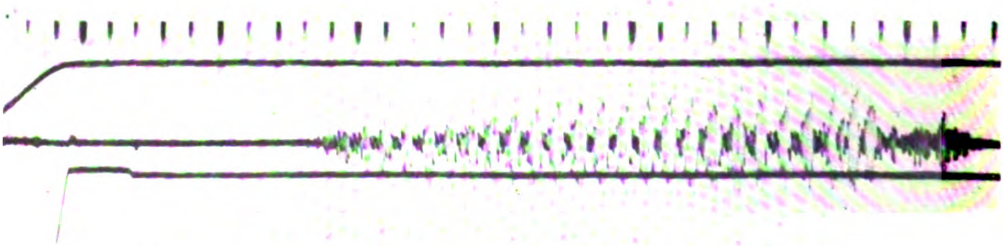
Should any special circuits be required for a particular test which are not wired to this section it is necessary only to change some of the cross-connections in the distributing frame to make them available. The patching section thus gives access to all the circuits which are commonly required and to other parts of the laboratory or building while the distributing frame multiplies and extends this function so that even the special equipment becomes readily available.

Many studies are made which involve the measurement of periods of time of the order of a thousandth of a second, such as the operating or releasing time of relays, or surges due to condenser discharge or to the breaking of inductive circuits. This



J. E. Devany supervising the work on an intermediate distributing frame

is most conveniently done with the oscillograph, of which two are kept continuously in use and a third is available for studies of trouble in the field or to carry peak loads in the laboratory. In 1927 over twelve thousand separate oscillograms averaging seven feet long were taken and analyzed by the engineers. This represents the application of the oscillograph to nearly seven hundred specific circuit

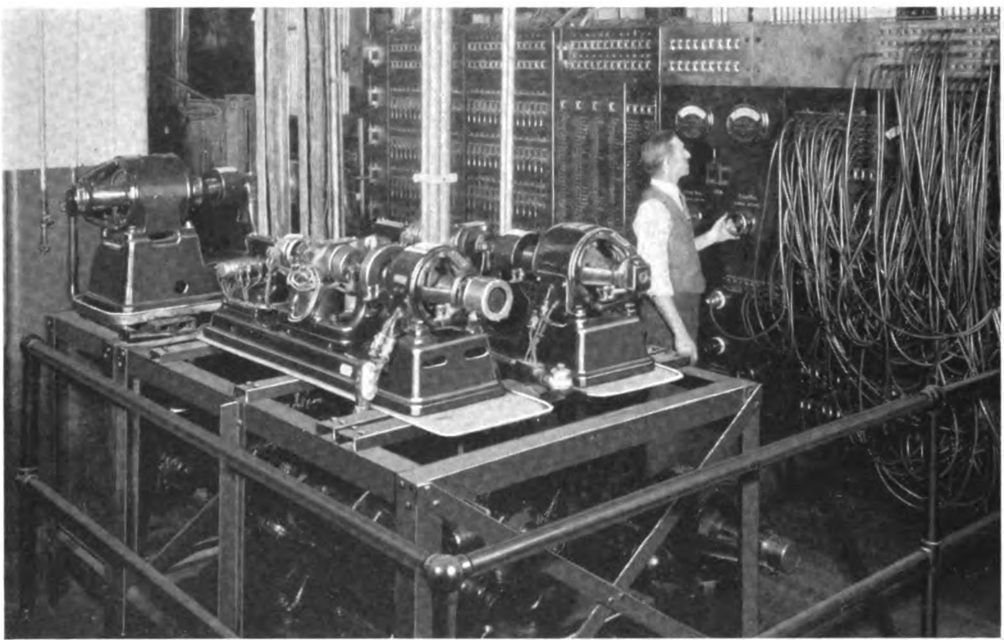


Oscillogram showing amplified speech and noise

problems. Many of these were made to determine time intervals, but others made use of the instrument as a voltmeter, ammeter, or in some cases as a wattmeter, as in the current-drain studies which were described in the January issue of the Record.

As it is impossible to secure accurately readable deflections on the oscillograph with currents less than about a hundredth of an ampere and as it is frequently necessary to study circuit conditions involving currents as low as a thousandth of an ampere or less, there is provided a three stage resistance-coupled amplifier which amplifies any frequency within the range of the vibrating-mirror oscillograph itself. This extends the use of the instrument to the study of currents of the order of those ordinarily produced by speech. The accompanying illustration shows how the oscillograph was used to determine the relative voltages produced by speech and by a disturbance on a subscriber's line. The peak at the right represents the disturbance while the rest of the trace was produced by speech in a normal tone over the same line.

A flexible and adequate power supply is, of course, a necessary adjunct to the circuit laboratory. For various alternating current requirements the laboratory is equipped with three standard central office ringing machines which supply both the ringing current and the familiar tones, and also with one of the latest types of direct connected ringing machines. Beside these there are three ringing machines for special studies, the frequencies and voltages from which are independently variable throughout the entire range of standard values. Various other special machines are available also such as inductor alternators for low frequency tone studies,



Power equipment showing ringing machines, interrupters, and power distributing board, with a few of the 250 cords up

and a vacuum-tube oscillator for frequencies from thirty-five to 75,000 cycles per second.

Except in special cases the laboratory depends on the central power room for its direct current supply. Fifty trunks are run from the power room to the multiple jacks on the Laboratories' power board, and these are cross-connected as desired. Switches are arranged so that any potential from one to fifty-six volts may be obtained as desired and higher voltages may be obtained if necessary by special connections. To make the power supply flexible one hundred and thirty circuits run from the power board jacks to the various benches and frames. These jacks may be connected by patching cords to the multiples which are supplied from the power room.

It is such facilities as these that make it possible for the Circuit Development Laboratory to carry on its work in the best fashion possible and to see that the standards of the Bell System are maintained in all new circuits issued.

Thus our tests carefully prepare the way for the field or trial installation. This is a subject worthy of a separate article in the RECORD; it is mentioned now only to bring out the fact that the trial installation does not, as the term might imply, serve to recheck the work of the Local Circuit Development Laboratory. The field trial places the new equipment or system in what is to be, as it were, its habitat by adoption, where its operation may be studied in conjunction with other equipment and with a flow of traffic and under conditions which it would be impossible to simulate within our laboratory.

Recognition of Achievements

Discussing the eight scientific achievements he considered outstanding in 1927, Sumner N. Blossom, editor of "Popular Science Monthly," named developments of the Laboratories for the first, second and eighth places, in an interview widely quoted in newspapers. In his opinion the gains in public convenience would be greatest from the year's advances in the field of communication. Television transferred from the field of conjecture to that of accomplishment, he placed first in value. Establishment of reliable two-way telephone service across the Atlantic ranked second. The remaining Laboratories achievement in the group was talking motion-pictures, whose use multiplied so greatly during the year.

Permalloy in Audio Transformers

By E. L. SCHWARTZ
Apparatus Development Department

THE use of permalloy for transformer cores has been a highly important contribution toward the high quality of the transmission now obtained in audio frequency transformers, both input and output. Although available for only a few years, this material has been used to a rapidly increasing degree. Since manufacturing information was issued on the first coded transformer using a permalloy core, other designs have been added continually so that now there are available manufacturing specifications for dozens of audio frequency transformers of that type, for use under different conditions. Several hundred special designs have been developed as well, for use in the Laboratories in circuits and apparatus where transmission of high quality is desired.

So rapidly has its use grown that permalloy is the core material in a large majority of the audio frequency transformers designed today. There are two principal reasons for its choice — desire for the best available transmission characteristic, and for reduction in size. Improvement of transmission quality has been the more influential of the two, but there have been a number of occasions where extreme compactness, such as could not be attained with a core of silicon steel, has been the primary consideration. Due to the high nickel content, however, permalloy costs considerably more than silicon steel.

The first commercially important demand for audio-frequency transformers whose frequency range exceeded the ordinary talking range of about 200 to 3000 cycles came in connection with the design of amplifiers for the Western Electric Public Address System a number of years ago. Although transmission requirements were not unusually severe according to present standards, the occasion marked the beginning of a rapidly increasing demand for many types of audio-frquency transformers possessing transmission qualities higher than had previously been necessary. Since then, the rapid increase in the development of loud speaking equipment, radio circuits and special amplifiers has made the electrical requirements for transformers constantly more rigorous with respect to the frequency range to be transmitted and to the uniformity of transmission over that range. One of the most exacting commercial demands has been met in transformers used in amplifiers for talking moving pictures apparatus, where there is demanded as nearly uniform transmission as possible between the frequencies of 40 and 6000 cycles. In addition there have been numerous special developments for which it has been necessary to design transformers giving uniform transmission over an even wider range; notable among these is the television system recently demonstrated, for which transformers were required

to transmit currents whose freqencies ranged from 10 to 20,000 cycles.

Importance of the core material in improving transmission at the lower frequencies is shown by the diagram of an input transformer the

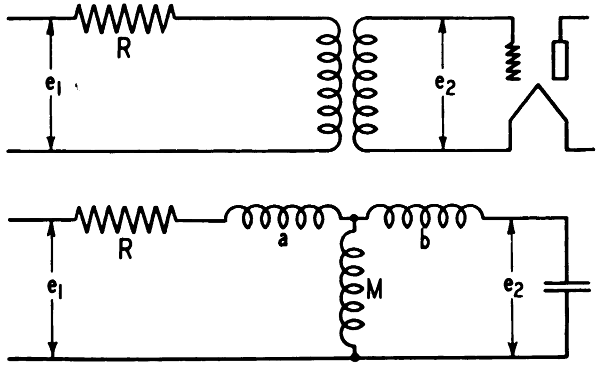


Figure 1, *above, and* 2, *below*

secondary of which is connected to a vacuum tube. Figure 1 is a schematic diagram, and Figure 2 the equivalent "T" network, where the condenser represents the input capacity of the tube and the distributed capacity of the transformer. The series arms a and b represent the primary and secondary resistances and leakage reactances, and M the mutual impedance between the windings. At low frequencies b can be neglected, and only the resistance component of a need be considered; this may be added to R, the resistance from which the transformer is working. It can readily be seen from this circuit that for the applied voltage to be transmitted without serious loss in the resistance R, the mutual impedance M must be large with respect to R. The value of M depends in turn principally on its reactive component, $2\pi fL$, where L is the mutual inductance of the transformer and f the frequency. As the frequency decreases, the impedance M obviously decreases as well; if it is to be kept high with respect to R, the important consideration is that L be made high. Thus the change from silicon steel to permalloy, by giving a core of higher permeability, raises L and M and so maintains the voltage amplification at frequencies where otherwise it would fall off badly. This merit of considerably higher permeability than that of silicon steel is confined however to low flux densities such as are ordinarily present in audio-frequency transformers.

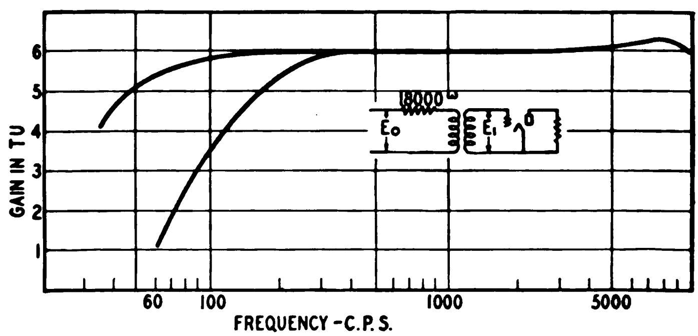
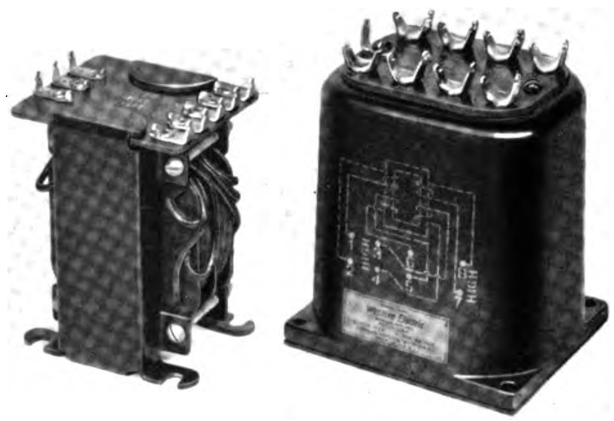


Fig. 3—*Effect of the core material on the voltage amplification characteristics of two input transformers. Upper curve, permalloy core; lower, silicon steel core. These curves, and those of Figs.* 4 *and* 5, *were taken with a superimposed direct current of* 0.002 *amperes through the primary winding*

The marked improvement in transmission quality of audio-frequency transformers which comes from the use of permalloy is readily seen from

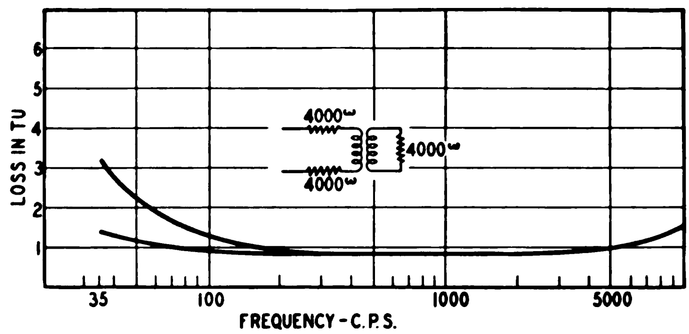
comparison of the voltage-amplification characteristics of two input transformers differing only in the magnetic materials used for their cores. These characteristics are recorded on the curves of Figure 3. It should be borne in mind that the transformer used does not embody the highest amplification quality available, but was chosen rather to indicate the improvement which can be made in the amplification of the lower frequencies by a change of core material. The same windings were used for both curves, and the cores themselves, the same in dimensions and construction, differed only in material; one was of silicon steel, and the other of permalloy. Each core was separable, and so after measurements had been made using one core it was removed from the windings and replaced by the other. In Figure 3, the lower curve represents measurements taken when the core laminations were of silicon steel, the material formerly used almost universally, and the upper curve represents data with laminations of permalloy. At frequencies as high as 300 the improvement from change of core material is noticeable, and at 60 cycles it is more than 4 TU. It will be noted that there is no noticeable change in amplification at the higher frequencies. Above 3000 or 4000 cycles the voltage-amplification characteristic is determined principally by design of the windings and is affected by change of the core material only to the extent that such a change permits modification of the winding design.

In the design of output transformers marked improvement in transmission at the lower frequencies, comparable to that for input transformers, can also be made under most conditions by the use of permalloy cores. Consideration must usually be given, however, to the necessity of carrying direct current of relatively large value from the plate circuit of the vacuum tube. Susceptibility of permalloy to the magnetizing effect of direct current is far greater than that of silicon steel. With input transformers, ordinarily, direct current is so small that if it cannot be neglected the design can be arranged to take care of its presence, but for output transformers the direct current usually must be kept out of the transformer windings or its effect must be balanced out by some such circuit arrangement as push-pull con-



Typical permalloy-core input transformers, potted and unpotted, weighing 2 and 3¾ pounds. Departure from this type has been mainly for output transformers required to transmit relatively large power and presenting correspondingly severe insulation problems; a few of these weigh as much as fifty pounds

nection of the vacuum tubes. Fortunately in many of the recent amplifier designs the tubes in the last stage are connected in push-pull to give the necessary power output; with this arrangement the direct currents from the two tubes pass through the windings in opposite directions, and so their magnetizing effects tend to neutralize each other. Of course perfect balance seldom results, but with tubes of average commercial quality the neutralizing effect is usually sufficient to assure a considerable part of the improved transmission characteristics made possible by the use of permalloy. In Figure 4, characteristics of output transformers are compared when the cores are of permalloy and of silicon steel. As before, there is no change in the windings, and the two cores are the same in size and shape, differing only in material. At the higher frequencies amplification is not changed, though an improvement could have been secured by change in design; the improvement would however have been at the expense of part of the gain at the lower frequencies.



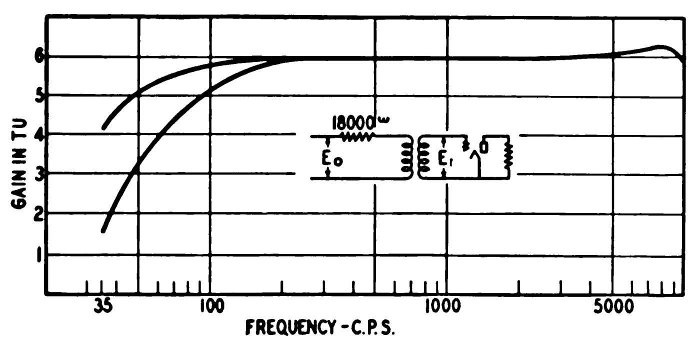


Fig. 4, above—Transmission loss characteristics of two output transformers. Lower curve, permalloy core; upper, silicon steel

Fig. 5, below—Voltage-amplification characteristics of input transformers with permalloy cores. Upper, core assembled with butt joints; lower, with interleaved construction

Use of a permalloy core is not of itself assurance of high-quality transmission at the lower frequencies; a substantial part of the improvement can be lost by use of a type of core assembly unsuitable for the conditions under which the transformer is to be operated. An example is illustrated in Figure 5. Two input transformers were used, with identical windings, and each with a permalloy core. The two cores in turn were made up of identical parts, but were assembled somewhat differently. In the first case, the laminations were assembled into two core units in the form of an E and I respectively. These were then placed together, with butt joints where they touched, imparting the effect of an extremely small air-gap. This gave the core sufficient stability to withstand the magnetizing effect of a small direct current in the windings. In the case of the other transformer, the same laminations were

assembled individually into a complete core, with the E and I pieces interleaved. The joints were thus alternated from side to side, and the effect of the air gap eliminated as far as possible. The result was an unstable magnetic circuit, with inductance higher than given by butt joint construction when there was no direct current but much smaller under actual circuit conditions, when a relatively small direct current flowed through the windings. Change to interleaved construction increased the loss at 60 cycles from 0.5 TU to 2.0 TU; such a loss in each input transformer of a Public Address System or an amplifier for talking moving pictures would of course be most objectionable. In output transformers, where appreciable direct current is usually present, selection of proper core design is even more important. Use of any transformer with permalloy core should be restricted to circuit conditions for which it is suited, since presence of an unsuitable condition such as is illustrated above when direct current is present may counteract in large part the benefits which the core material would otherwise bring, and render its use of little value.

A French Appreciation of the Bell System

Monsieur Drouët, Inspector General of Posts and Telegraphs of France, in his preface to E. M. Deloraine's French translation of K. S. Johnson's "Transmission Circuits for Telephonic Communication," gracefully acknowledges the indebtedness of the world to the United States and particularly to the American Telephone and Telegraph Company for the development of telephonic communication.

"Un groupement industriel et financier très puissant s'y est progressivement constitué autour de l'American Telegraph and Telephone Co., qui exploite aux Etats-Unis les communications à grande distance. Ses services techniques, et ceux des Sociétés qui lui sont affiliées, comprennent un état-major d'ingénieurs de premier ordre, et certains d'entre eux sont des savants dont l'autorité s'est imposée dans tous les pays.

"De ce groupement d'hommes de valeur, qui mettent en commun leurs efforts pour le perfectionnement d'une même technique, on pourrait dire qu'il constitue une véritale confrérie intellectuelle qui développe et propage, en matière de communications électriques, une doctrine dont la valeur est hautement apprécipée par tous les spécialistes."

He speaks of their technical staff, in which he includes Bell Telephone Laboratories, as engineers of the first order who constitute an intellectual brotherhood for the development of matters pertaining to electrical communication.

Recent Technical Papers

During the past year, a large number of papers by members of Bell Telephone Laboratories presented before professional societies have been published in their journals. Those listed below have not been noted currently in the Record.

Diffraction of Electrons by a Crystal of Nickel—C. J. Davisson and L. H. Germer. *Physical Review, December,* 1927.

A Note on the Thermionic Work Function of Tungsten—C. J. Davisson and L. H. Germer. *Physical Review, November,* 1927.

The Scattering of Electrons by a Single Crystal of Nickel—C. J. Davisson and L. H. Germer. *Nature, April* 16, 1927.

The Thickness of Spontaneously Deposited Photoelectrically Active Rubidium Films, Measured Optically—H. E. Ives and A. L. Johnsrud. *Journal of the Optical Society of America, December,* 1927.

A Photoelectric Process of Halftone Negative Making Applicable over Telephone Lines—H. E. Ives. *Journal of the Optical Society of America, August,* 1927.

Plane Waves of Light—I—Electromagnetic Behavior—Thornton C. Fry. *Journal of the Optical Society of America, September,* 1927.

Plane Waves of Light—II—Reflection and Refraction—Thornton C. Fry. *Journal of the Optical Society of America, January,* 1928.

On Electrical Fields and Metallic Surfaces—J. A. Becker and D. W. Mueller. *Physical Review, February,* 1928.

Precision Determination of Frequency—J. W. Horton and W. A. Marrison. *Proceedings of the Institute of Radio Engineers, February,* 1928.

Frequency Measurements with the Cathode Ray Oscillograph—F. J. Rasmussen. *Journal of the American Institute of Electrical Engineers, January,* 1927.

The Short Wave Limit of Vacuum Tube Oscillators—C. R. Englund. *Proceedings of the Institute of Radio Engineers, November,* 1927.

The Propogation Characteristics of Sound Tubes and Acoustic Filters—W. P. Mason. *Physical Review, February,* 1928.

A Direct Comparison of the Loudness of Pure Tones—B. A. Kingsbury. *Physical Review, April,* 1927.

Observation of the Microstructure of the Path of Fatigue Failure in a Specimen of Armco Iron—F. F. Lucas. *American Society for Steel Treating, Transactions, April,* 1927.

Submarine Cable Insulation with Special Reference to the Use of Rubber—R. R. Williams and A. R. Kemp. *Journal of the Franklin Institute, January,* 1927.

Direct Determination of Hydrocarbon in Raw Rubber, Gutta Percha and Related Substances—A. R. KEMP. *Industrial and Engineering Chemistry, April,* 1927.

The Significance of the Dielectric Constant of a Mixture. H. H. LOWRY—*Journal of the Franklin Institute, March,* 1927.

The Densities of Coexisting Liquid and Gaseous Carbon Dioxide and the Solubility of Water in Liquid Carbon Dioxide—H. H. LOWRY AND W. R. ERICKSON. *Journal of the American Chemical Society, November,* 1927.

Absorption of Water by Rubber—H. H. LOWRY AND G. T. KOHMAN. *Journal of Physical Chemistry, January,* 1927.

The Adsorption of Gases by Solids with Special Reference to the Adsorption of Carbon Dioxide by Charcoal—H. H. LOWRY AND P. S. OLMSTEAD. *Journal of Physical Chemistry, November,* 1927.

Effect of Moisture on Electrical Properties of Insulating Waxes, Resins and Bitumens—J. A. LEE AND H. H. LOWRY. *Industrial and Engineering Chemistry, February,* 1927.

Brittleness Tests for Rubber and Gutta-Percha Compounds—G. T. KOHMAN AND R. L. PEEK, JR. *Industrial and Engineering Chemistry, January,* 1928.

Structure of a Protective Coating of Iron Oxide—R. M. BOZORTH. *Journal of the American Chemical Society, April,* 1927.

The Solid Solubility of Antimony in Lead as Determined by Conductivity Measurements on Cold-Worked Alloys—E. E. SCHUMACHER AND G. M. BOUTON. *Journal of the American Chemical Society, July,* 1927.

An Efficient Apparatus for Measuring the Diffusion of Gases and Vapors through Membranes—E. E. SCHUMACHER AND L. FERGUSON. *Journal of the American Chemical Society, February,* 1927.

The Electric Moments of Substituted Benzene Molecules and the Structure of the Benzene Ring—C. P. SMYTH AND S. O. MORGAN. *Journal of the American Chemical Society, April,* 1927.

News Notes

THE ADDRESS which Dr. Jewett delivered before the Alumni Dinner of Massachusetts Institute of Technology is published in the March issue of *The Technology Review* under the title "Scientific Education." On February 28 Dr. Jewett spoke on "Some Facts and Fallacies about Industrial Research" before a Luncheon Meeting of the Philadelphia Engineers Club.

J. C. HUNSAKER was the host of Col. Stedman S. Hanks, President of the American Airports Corporation, when the latter visited the Laboratories on March 9.

SYSTEMS DEVELOPMENT

L. F. PORTER made tests on No. 3 toll circuits at Reading, Pennsylvania.

H. J. FISHER is in London, England, conducting tests on new improvements on the transatlantic circuits.

G. W. AMES left on February 20 for Denver, Colorado, to study field conditions on broadcasting circuits routed over transcontinental telephone lines.

C. D. WALKER was in Chicago, discussing plans for the installation of a new power plant for the enlarged Chicago Toll Office with engineers of the Illinois Bell Telephone Company.

H. M. SPICER spent two days in Waltham, Massachusetts, discussing voltage control equipment with the Palmer Electric and Manufacturing Company.

T. C. CAMPBELL spent the first week in February studying trouble conditions on panel selector frames in the Chicago dial offices.

R. P. JUTSON visited Kane and Erie, Pennsylvania, and Newark, Ohio, where he studied the use of small automatic power plants in various types of power service.

H. D. BRUHN visited the first No. 701-A P. B. X. to be installed in Chicago on February 13.

V. T. CALLAHAN investigated emergency gas engines in Schenectady and Utica, New York.

F. R. DICKINSON arranged for the new grouping of transmission measuring equipment in the new Cleveland Toll Office.

C. W. VAN DUYNE visited the Westinghouse Electric and Manufacturing Company at Pittsburgh to discuss development features of an emergency charging set driven by kerosene engines.

GENERAL STAFF

DURING SCHOOLMEN'S WEEK at the University of Pennsylvania, John Mills addressed the science sections on "Physics and Chemistry of Television."

S. P. GRACE spoke before the New York Electrical Society on recent developments in the Laboratories, on March 9.

R. W. KING lectured before the Wednesday Club of St. Louis on March 14, on the subject "Research and Development at Bell Telephone Laboratories."

Patent

During October, November, December, January and February patents were issued to the following members of the Laboratories staff:

H. D. Arnold
E. P. Bancroft
E. L. Baulch
F. S. Bernhard
C. H. Berry
W. L. Betts
H. S. Black (2)
D. G. Blattner (2)
O. E. Buckley (2)
R. M. Burns
E. T. Burton
W. W. Carpenter
R. W. Chesnut
E. H. Clark
A. M. Curtis
J. W. Dehn
R. W. DeMonte (2)
H. F. Dodge (2)
A. D. Dowd
T. J. Engel
J. F. Farrington (5)
J. C. Field (2)
H. J. Fisher
J. W. Foley (2)
W. Fondiller
C. B. Fowler
H. A. Frederick
H. T. Friis
J. O. Gargan (2)
J. S. Garvin
E. W. Gent (2)
J. J. Gilbert
A. F. Gilson
H. W. Goff (2)
J. W. Gooderham
C. L. Goodrum
W. S. Gorton
Frank Gray
C. W. Green
T. R. Griffith
A. Haddock
A. E. Hague
L. N. Hampton
H. C. Harrison (3)
R. V. L. Hartley (2)
R. A. Heising (3)
E. E. Hinrichsen (2)
J. W. Horton
H. Hovland
F. A. Hubbard
H. E. Ives (5)
K. S. Johnson
W. C. Jordan
A. R. Kemp (2)
D. H. King
J. J. Kuhn
F. A. Kuntz
A. G. Landeen
W. G. Laskey
V. E. Legg (2)
M. B. Long
G. T. Lorance
H. H. Lowry (2)
G. R. Lum
D. MacKenzie
W. H. Manthorne
W. A. Marrison
G. R. Martin
R. C. Mathes (3)
D. T. May
E. D. Mead
D. D. Miller (2)
John Mills (2)
C. E. Mitchell
C. R. Moore (3)
E. R. Morton
R. Nordenswan
A. A. Oswald
R. E. Peoples
H. Pfannenstiehl
W. A. Phelps
R. L. Quass
H. T. Reeve
G. Riggs
J. G. Roberts
F. M. Ryan (2)
J. P. Schafer
J. C. Schelleng
P. Schwerin
W. J. Shackleton (2)
O. A. Shann
T. E. Shea (2)
J. B. Shiel
H. O. Siegmund (2)
L. J. Sivian
A. B. Sperry
C. A. Sprague
F. A. Stearn (2)
C. W. Stevens
R. L. Stokely (2)
W. J. Thayer
H. W. Ulrich (2)
H. Vadersen
C. G. Von Zastrow
F. A. Voos
E. Vroom
R. L. Wegel
E. C. Wente
E. B. Wheeler
R. S. Wilbur
F. C. Willis
I. G. Wilson

G. H. Heydt, G. T. Morris, T. P. Neville, J. C. R. Palmer, P. C. Smith and E. Woodbury were in Washington, D. C. from February 8 to March 13 in connection with the prosecution of applications for patent. During the same period G. H. Stevenson and W. G. Crawford visited Philadelphia and Camden, respectively.

Inspection Engineering

W. C. Miller and R. M. Moody attended regular Survey Conferences at Hawthorne during the early part of March. H. F. Kortheuer and T. Mellors attended a similar conference at Kearny.

G. D. Edwards and R. J. Nossaman visited the Cleveland, Detroit and Chicago field territories during the first two weeks in March, and discussed general field activities with Telephone Company engineers and Western Electric Distributing House men in Detroit, Indianapolis, and Columbus. Mr. Nossaman also visited field headquarters at St. Louis and Cleveland.

A. I. Rivenes, formerly Local Engineer in the Chicago field territory, has resigned to become Division Traffic Engineer of the Chicago Area for the Illinois Bell Telephone Company.

I. W. Whiteside, formerly Field Engineer at Detroit, has been appointed Field Engineer in the territories of the Illinois Bell Telephone Company and the Wisconsin Telephone Company, replacing A. I. Rivenes. Mr. Whiteside's headquarters will be in Chicago.

R. C. Kamphausen has been appointed Field Engineer in the territories of the Michigan Bell Telephone Company and the Indiana Bell Telephone Company, replacing I. W. Whiteside. Mr. Kamphausen's headquarters will be in Detroit.

Outside Plant Development

R. L. Jones, C. D. Hocker, and V. B. Pike, with G. A. Anderegg and E. E. Schumacher were in Philadelphia on February 28 to observe a demonstration of a proposed new method of joining cable sheath.

E. M. Honan and A. R. Kemp visited New Haven and Bridgeport on March 1 and 2 to study development of rubber covered wire.

I. C. Shafer was in New Haven on February 29 in connection with development problems involving drop wire attachments.

J. M. Hardesty attended the annual meeting of the American Concrete Institute in Philadelphia, from February 28 to March 1.

L. W. Kelsay and W. W. Werring were in Bridgeport on March 1, studying proposed improvements in connecting blocks.

E. M. Honan and A. R. Kemp attended a meeting of the Rubber Committee of the American Society for Testing Materials on March 15 and 16.

C. D. Hocker attended a committee meeting of the American Society for Testing Materials in Philadelphia on March 9.

Apparatus Development

H. W. Goff and J. F. Hearn recently visited the American Brass Company plant at Waterbury, Connecticut to observe new methods of arc welding.

C. G. McCormick was in Chicago during the second week of February to discuss questions on step-by-step apparatus with representatives of the Automatic Electric Company and to obtain information on apparatus at Western Electric, Hawthorne.

James Abbott and C. J. Hendrickson visited Philadelphia on February 20 to confer with engineers of the Western Electric Installation Department at the Baring office on dial testers installed there.

H. S. Price supervised the installation of a master oscillator unit in the five-kilowatt broadcasting equipment of the U. S. Playing Card Company in Cincinnati. He also inspected the five-kilowatt broadcasting station of the Stromberg-Carlson Telephone Manufacturing Company at Rochester.

H. M. Stoller lectured on Television before the Rochester section of the A. I. E. E. on March 2.

J. C. Field spent several weeks in North Dakota working on the train dispatching system of the Minneapolis, St. Paul & Sault Ste. Marie Railroad Company. On his way east he made an investigation of the selector supervisory system used by the Illinois Central Railroad Company.

P. H. Pierce was the author of an article on "Some Applications of Vacuum Tube Amplifiers" which appeared in the February issue of *The Nebraska Blue Print.*

T. E. Shea is spending the first half of each week lecturing before a class on "Transmission Networks" at Massachusetts Institute of Technology. The class includes over thirty students and is also attended by about twelve members of the faculty.

W. W. Werring has been appointed to the Committee on Standardization of Impact Testing Methods of the American Society for Testing Materials.

H. O. Siegmund visited Hawthorne on March 14 to confer on contact design.

W. Fondiller, F. F. Lucas, H. N. Van Deusen and J. E. Harris

visited Kearny on March 14 to inspect developments in the extrusion of lead cable sheath, and thermal control of the lead presses.

Research

L. J. Cobb visited Hawthorne on March 11 to set up equipment for testing No. 4-A electrical reproducers. W. C. Jones and L. A. Morrison later went to Hawthorne to observe the manufacture of these reproducers.

E. G. Shower visited the Johns Hopkins Hospital at Baltimore to inspect apparatus used in various phases of work on audition.

C. R. Moore was at Hawthorne from March 3 to 11 in connection with work on broadcast transmitters.

R. M. Burns attended a conference on electroplating at the Bureau of Standards in Washington, on March 2.

W. G. Knox witnessed trials of the application of sprayed lacquer in refinishing housings of subscriber sets in Philadelphia on February 27.

F. F. Farnsworth and C. L. Hippensteel attended meetings of the metal section of the American Society for Testing Materials in Washington on March 21 and 22.

R. M. Burns and F. F. Farnsworth with H. N. Van Deusen of Apparatus Development studied the effect of corrosion on central office equipment in Altoona, Pennsylvania, and Atlantic City, New Jersey.

H. E. Ives lectured on television before the Naval Post-Graduate School at Annapolis on March 2, at the University of Kansas on March 5, and before the St. Louis section of the A. I. E. E. on March 8. On March 20 and 21 he spoke before the students and faculty of Yale.

H. D. Arnold lectured on "Recent Researches in Communication" before a joint meeting of the Middletown Science Society and the Physics Department of Wesleyan University in Middletown, Connecticut, on March 13.

E. F. Kingsbury gave a short talk on television before the Women's Reading Club of Rutherford, New Jersey, on March 30.

C. J. Davisson spoke on "Diffraction of Electrons by a Crystal of Nickel" before the Philosophical Society of Washington, D. C., on March 31.

F. Gray spoke on television before a joint meeting of the Exchange Clubs of Scranton and Wilkes-Barre in the latter city on March 20.

On February 29, C. T. Wood addressed the Men's Club of the Broadway Tabernacle on "The Dance of the Electrons."

E. M. Noll visited the Henry L. Scott Company at Providence on February 14 to discuss operational details of the rubber compression machine which is being built there for the Laboratories.

M. J. Kelly addressed the Colloquium at Massachusetts Institute of Technology on March 5 and 6, on "Thermionic Filaments of Vacuum Tubes Used in Wire Telephony."

Frank Gray lectured on "Television and the Electrical Transmission of Pictures" at the Brooklyn Academy of Music on March 31, under the auspices of the Alfred Waters Proctor Foundation.

R. R. Williams spoke at the Colloquium on March 5, on "Conduction of Electricity in Textile Insulations"; and on March 19, J. C. Schelling spoke on "Recent Developments in Radio Transmission."

Club Notes

The 1927-28 basketball season was completed on Tuesday evening, February 28, when the team representing the Equipment Branch of the Systems Development Department and that of the Commercial Department played for the Club Championship. This year the league season was divided into halves, of which the Equipment Department won the first and the Commercial Department the second. Equipment won the deciding game by a score of 28 to 18 before a large and enthusiastic gathering, and now has two legs on the trophy. To the Equipment men also went the individual prizes. The final standing in the league was as follows:

	Won	*Lost*
Equipment	11	1
Tube Shop	9	3
Commercial	8	4
Research	5	7
Toll and Circuit	4	8
Apparatus Development	3	9
Junior Assistants	2	10

First Ten Individual High Scorers

	Field Goals	Foul Pts.	Total Pts.
MacCullough—(Toll and Circuit)	13	18	44
Nichols—(Commercial)	49	14	112
Kontis—(Tube Shop)	47	12	106
Smith—(Apparatus)	33	2	68
De Angelis—(Research)	31	5	67
Lohmeyer—(Apparatus)	29	5	63
Elliot—(Research)	26	10	62
Smith—(Tube Shop)	27	6	60
Ottoman—(Equipment)	19	14	52
Bodtlander—(Jr. Assistants)	22	7	51

Hiking

For those who have shared the joy of following trails through wood and meadow to a blazing campfire and a supper beneath the stars, there is no need of a pressing invitation to join the hiking club. Others who are interested will find a warm welcome, and friends of members are invited to come.

Some of our hikers anticipated the opening of the official season and, under the leadership of Bob Bogumil, spent Washington's Birthday at Bear Mountain, where skiing, tobagganing, and ice-skating were in order. On the same day, another group hiked to Silver Lake, White Plains, where W. C. Buckland and F. R. Stansel prepared an old-fashioned clam chowder.

Though hiking is its own reward, a splendid trophy is to be awarded this year to the best hiker among the men and another to the women. Choice will be made from those hiking the greatest distance in the season, by vote of those covering fifty miles on Club hikes. All who hike one hundred and twenty-five miles are to be the guests of the Club on a special hike at the end of the season.

The spring program will begin on Saturday, April 14, with a ten mile hike from Piermont to Alpine, the objective being a campfire supper with Phyllis Barton as hostess. The cost of transportation and supper will be about one dollar and fifty cents. On Sunday, April 22, the group will hike by trail under the leadership of Trevor Temple from Suffern to Tuxedo through the picturesque Ramapo Mountains. The cost of transportation will be about two dollars. Please call Phyllis Barton or A. Grendon if you wish to attend either.

Printed copies of the complete hiking schedule for the spring may be obtained on request.

Baseball

The Bell System Baseball League will open the 1928 season on Monday evening, April 30, at Erasmus Field, Brooklyn. This year the league is composed of fourteen teams and is divided into two groups of seven teams each. Games will be played each week on Monday, Tuesday, Thursday and Friday evenings starting promptly at 6 P. M. All members of the Laboratories are invited to attend these games.

Track and Field

The Bell System Baseball League will promote an intercompany track and field meet at Erasmus Field on Saturday afternoon, June 16.

WOMEN'S ACTIVITIES

Dancing

The dancing class continues every Monday night at the Vecchio Studio, where the "Varsity Drag" is the latest subject for study.

Swimming

The new term for Women's Swimming Classes will start Monday, April 4. There will be two classes a week, and the course, which will extend over a period of ten weeks, will afford a splendid opportunity to put in some intensive training for the summer vacation. For application blanks see Miss Steel, Section 1-G.

Bowling

The women bowlers of the Laboratories are most enthusiastic about the arrangements made for them by the Bell Laboratories Bowling League. Four teams selected in a contest held on February 24 have been scheduled to bowl at Dwyers on Friday evenings for six weeks ending April 6. A member of the Bowling League has been present to instruct the beginners, and there has been marked improvement in the scores since the first games. The women's teams are represented on the executive committee of the Bowling League by Helen Cruger and Marie Boman.

Basketball

With a record of having won six games out of nine, the Women's Basketball Team has completed the 1927-28 season with a success hitherto unattained. This season, which has meant the first real attempt at outside competition, has opened up an avenue leading to future attractive and spirited programs in women's basketball. The first five games were successive victories for the Laboratories Club Team, which defeated teams of the Southern Division of the New York Telephone Company, the Vacuum Oil Company, the Seaboard National Bank, Hudson Street branch of Western Electric, and the Union Carbide and Carbon Corporation. Then followed defeats by the People's Palace and the Federal Reserve Bank. In a return game with the Southern Division of the New York Telephone Company the Laboratories Team was again victorious. In the final game, Hempstead High School Alumnae were winners; they exemplify the type of team we are preparing to meet next season.

Gold basketballs were awarded to eleven members of the squad.

The St. Francis Dam Disaster

The prompt handling of a terrific rush of urgent calls was instrumental in saving the lives of hundreds of people trapped in the valley of the Santa Clara River during the recent flood. Though the telephone offices were in imminent danger of being swept away by the deluge, the operators stayed at switchboards, transmitting warnings, and notifying the local constables to spread the general alarm.

Lines and equipment suffered badly, and orders were given to spare nothing in the effort to restore service. The first line went down at 12:45 *Tuesday morning. By noon one hundred repairmen were on the job, and fifteen truckloads of insulated wire for temporary use had arrived in the flood area. As part of the day's work, two telephone men swam across a fifty-foot torrent of water to start repair of the San Francisco-Los Angeles circuits. By six o'clock in the evening all of the circuits on the inland route, which carry a great part of the telephone and telegraph load from southern California to the north, were restored by the use of temporary insulated wires laid on the ground and through water. Special telephone and telegraph circuits were installed to take care of the Red Cross, news agencies, and the Governor and his staff.*

BELL LABORATORIES RECORD

THE DECODER
By R. Raymond

RECORDING HEART SOUNDS
By D. G. Blattner

SPECTROGRAPHIC ANALYSIS
By E. E. Schumacher

MAY 1928 VOL. 6 NO. 3

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The Decoder

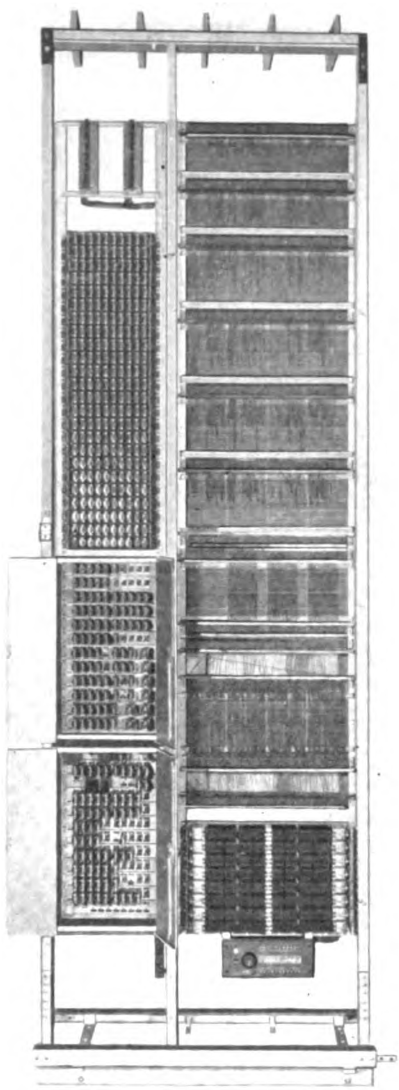
By R. RAYMOND
Systems Development Department

TELEPHONE numbers in all larger cities have two parts: an office name, and a subscriber's number. In manual exchanges, after the operator has heard the number you want, she selects from the many outgoing trunks in front of her one running to that particular office and then gives the number to the operator at that office who completes the call. In dial-type offices the sender, which has been called the brains* of the "panel" system, performs the work of these two operators. It has no difficulty in handling the second part of the number by itself, but to locate the proper office it requires help. For this it may now turn to the decoder, a new piece of equipment designed to replace the translator frames and pulse machines used heretofore. Carrying out the simile, the decoder could be called the memory of the panel system. It serves as a sort of card index to which the sender refers for the information it requires regarding the routing and procedure for each call.

* *A Mechanical Brain,* Bell Laboratories Record, *November,* 1926, *p.* 78.

In the large areas using panel equipment, each subscriber's number requires seven or eight dialing operations: three to locate the central office, and the remaining four or five to locate the individual line within that office area. The decoder is not at all concerned with these last four numbers which through relays in the sender cause apparatus located in the called office to select successively the group of two thousand that includes the subscriber being called, then the five hundred, the hundred, the ten, and finally the individual line. The method is not unlike the one you use to locate a friend when you walk down his street till you reach the building he is in, then up to the proper floor, down the corridor to the right office, and finally in to the individual desk he occupies.

This simple and straightforward method does not prove practical, however, for locating the called office because office names depend on the location of the office or on other factors that are in no way related to the terminating position of their trunks in the switching equipment.



The decoder itself is a collection of from three hundred to four hundred relays with a cross-connection rack; it has no power-driven apparatus

The Whitehall and Washington Heights offices, for instance, have a similarity in name, as both begin with "W", although there may be no similarity whatever in the position of their cable terminals in the switching equipment of the Chelsea office. Other factors too, such as whether the called office is a manual or panel office, are independent of the office name but must be considered in sending the call. In addition the equipment to locate the office trunks needs to be in use a shorter time than the equipment for calling the number, and all these factors make it a practical necessity to have a translating device as a separate unit. Only six decoders are used for as many as four hundred senders.

With a three-letter code to indicate the office there are 512 combinations that may be dialled, of which about four hundred are suitable for office names. The sender records the three sets of impulses sent out when the subscriber dials the office letters and then turns to the decoder and allows it to decode these signals and, as a result of the information it gains thereby, to pick out the proper trunk. After this the sender proceeds with the selection of the called number.

Suppose an Ambassador subscriber wishes to call Bell Telephone Laboratories, Chelsea 1000. As soon as the dial has been pulled three times to register the office code, 2-4-3, (C-H-E) the sender attaches itself to any one of the decoders that is not then in use. This requires the simultaneous connection of about fifty wires followed by the operation of a combination of relays in the decoder corresponding to the code 2-4-3. The action of this relay combination then operates a relay in the decoder known as a route relay of which there is one for each outgoing route to another central office or to an operator.

Returning to the conception of the decoder as a card index, this particular route relay is the card for Chelsea Office or code 2-4-3 and if it were

a printed card, it would contain the following information:

1. There is such an office and the Ambassador subscribers are allowed to dial it.

2. There is a group of trunks direct from Ambassador to Chelsea which are to be reached by choosing the third brush and the first group on the district selector frame and then the second brush and the eighth group on the office selector frame.

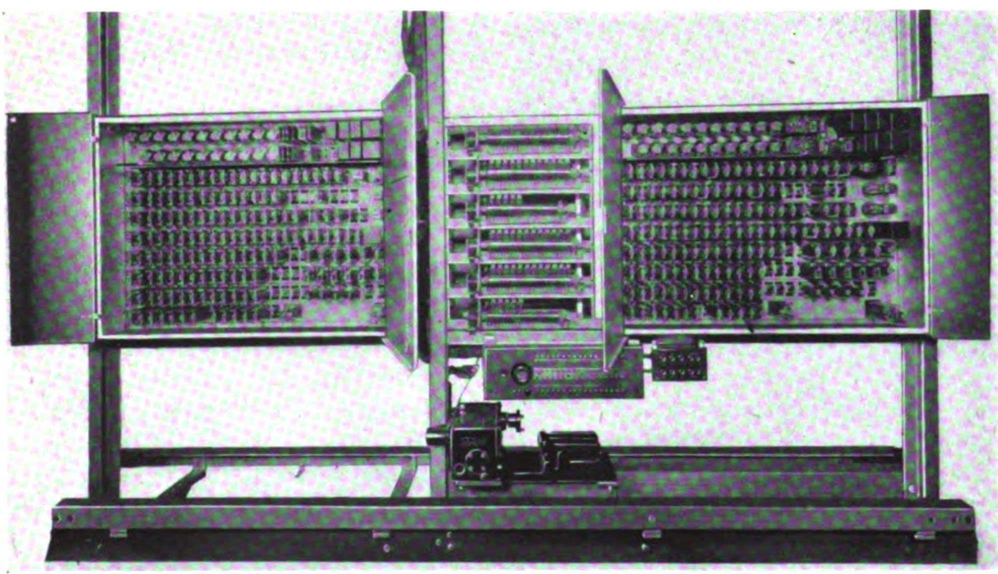
3. As Chelsea is a manual office, the sender must transmit the called number to it by impulses of a kind to display the number (in this case 1000) on lamps before the operator.

4. The office selector frame is very near the sender (both in Ambassador Office) and therefore in operating the office selector, the sender must add a certain resistance to the circuit to make the relays operate properly. But Chelsea is so far away that no resistance should be added when transmitting impulses to it.

5. Chelsea has no party lines, but it has numbers between 10,000 and 10,499. Since the sender cannot tell whether the subscriber is going to call 1,000 or 10,000, it must wait a few seconds to give him time to dial a fifth numerical digit before signalling the Chelsea operator. But if the subscriber calls Chelsea 2000, it is not necessary for the sender to wait this time since there are no such numbers as 20,000 and no party line stations such as 2000-J.

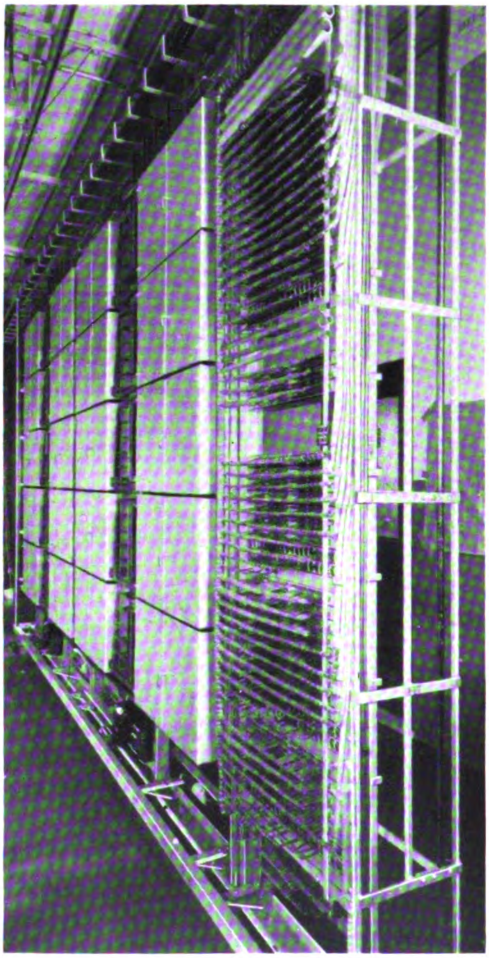
6. The sender must notify the district selector to supply repeating-coil transmission, and if the call is answered to operate the Ambassador subcriber's message register.

Cards for other codes might contain information that the called office was a full mechanical one requiring a different kind of impulses to transmit the number. They might carry information that there was no office selector in the route or that the office selector was of the two-wire



One sender unit of two senders which is assembled, wired, and tested in the factory and then mounted on the frame with four others by the assembler

variety requiring somewhat different treatment from the local three-wire office selector. They might include the note that there were no direct trunks to the called office, and that it must be reached through a tandem office. Some of them might convey the fact that the office concerned may be



Two sender frames including twenty senders, and one connector frame in the trial installation in Brooklyn

dialed by one class of Ambassador subscriber but not by another class. When the route relay operates, its contacts, which are interchangeably cross-connected, cause other relays in the decoder to operate, which ground a certain selection of the wires connected to windings of relays in the sender. The combination of these relays which are thus operated, records in the sender all that it needs to know to connect the calling subscriber to Chelsea Office. The connection between sender and decoder is then broken.

This is in brief what the decoders do for every call registered in the senders: they take the office code, decode it and return full information to the sender. This requires about three-tenths of a second, and if supplied with a steady stream of calls, one decoder will handle 12,000 an hour. In practice, the calls do not come in a perfectly steady stream and to attempt to handle them at that rate would cause excessive delays to some of them. It is proposed, however, when the maximum equipment of six decoders is provided, to load them during the busy hour at nearly 8,000 calls per decoder. If one of the six should be out of service due to trouble, the load could still be handled without noticeable delays.

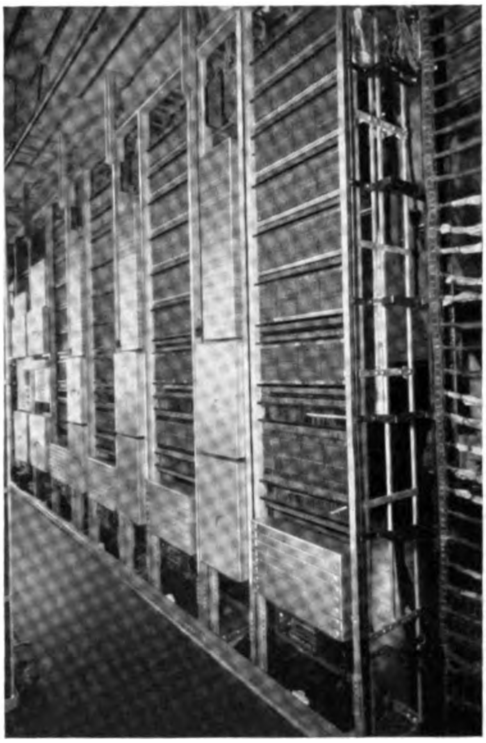
When handling calls at this rate, a decoder which develops trouble, such as a break or cross in its wiring or a dirty relay contact, could misroute or fail to route a great many calls in a short time unless precautions were taken to prevent it. A so-called second trial feature is incorporated in the design of the decoder and sender to prevent even one call from going astray due to such a fault. A system of alarms is provided to call the attention of the maintenance force to any faults arising in the decoders or the connectors which serve as the link between them and the senders

and to assist in locating such faults.

In handling each call, the decoder automatically tests all the wires connecting it with the sender, and if a fault exists it refuses to proceed. It will also fail to proceed if there is any fault within the decoder itself. A time-measuring device allows the decoder a certain short time to complete its work on every call and if it does not do so in that time, it sends a signal to the sender to make a second trial. This means to disconnect from the decoder and try again with another decoder. If the second trial is unsuccessful, the fault must be in or near the sender, not in the decoder, and the sender sticks without making a third trial. This feature practically eliminates lost calls due to troubles in the decoders or in that part of the connector which is near the decoders.

With the old-type senders, the decoding was done by means of translator frames and pulse machines. Each sender had a panel-type selector on the translator frame which was run up to a certain level depending upon the office code dialed. At that level, it connected the sender by six wires to the commutators of the motor-driven pulse machine, which sent six sets of pulses in turn over the six wires, operating a selection of thirty-six relays in the sender.

The essential differences between the pulse machine and decoder principles of operation are two. First, the pulse machine sender has an individual clutch-driven selector to record the office code, whereas the decoder sender transmits the code by grounding a selection of leads to relays in a common decoder. Secondly, the pulse machine operates relays in the sender in successive batches by pulses of current of short duration,



Three decoders of the trial installation and at the extreme left the decoder test frame

whereas the decoder operates relays in the senders all together by currents of more ample duration. The decoder equipment has no moving apparatus except relays and these are all furnished operating currents far in excess of their needs in respect to both volume and duration. The decoder is proving successful in its trial installation in the Ambassador Office, Brooklyn, where it has been in service since the first of September, 1927.

Differential Equations and Law

By THORNTON C. FRY
Research Department

MATHEMATICIANS and lawyers both find it necessary to define curves. Mathematicians sometimes do it by the use of differential equations and sometimes by the use of algebraic equations. Lawyers always use differential equations. That is one difference between the two professions. Another is the charge they make for their services; but that is beyond the scope of this article, which is intended to explain how the differential equations used by mathematicians (and by lawyers) succeed in defining curves.

I own a certain building lot. The boundary of this lot is a curve. From a strictly logical standpoint it would be possible to prescribe that boundary by giving the latitude and longitude of every point on it. It is true that there are an infinity of points and we could not handily make a table which lists them all, but we might think up some other scheme that would accomplish the same end. We might say, for instance, that along one side of my lot the sum formed by adding the longitude to half the latitude was equal to 115 degrees. We could even save space by letting x represent longitude and y latitude and writing the equation

$$x + \tfrac{1}{2}y = 115. \qquad (1)$$

This algebraic equation would accomplish the same end as a table and would be much simpler to construct.

The lawyers who drew the deed to my lot, however, did not see fit to define its boundary in any such way. Instead they first announced that there was a marble "monument" buried in the ground at one corner of it, and then said "beginning at this monument proceed so many feet in a certain direction, then so many more feet in another direction, and so on until the monument is again reached." This is a differential equation all written out in words — and it is, in addition, a "boundary value."

Now these two methods of prescribing the curve in question are equally precise but they are essentially different. For example, the first method is of such a character that it is possible to decide at once whether a particular point is or is not on the curve without reference to any other point whatsoever. All that is necessary is to substitute its latitude and longitude in the equation (1) and this is identical in principle with looking them up in our hypothetical table of boundary points. The second method, on the other hand, is of such a nature that this cannot be done. To find whether a particular point is or is not on the boundary it is necessary to start from the monument and walk in the prescribed direction until either we reach the point in question, or else are quite sure we never shall. In doing this, however, we obviously locate many other points of the boundary which are quite likely to be of no immediate interest.

Mathematicians sometimes define

curves in this way. In other words, they sometimes talk about direction as well as latitude and longitude; and just as they use the letters x and y as abbreviations for latitude and longitude, they use y' as an abbreviation for direction. Take, for example, the "differential equation"

$$y' = x + y. \qquad (2)$$

It has nothing to do with the boundary of any lot, but it may serve to illustrate the mathematician's point of view. Suppose we are located at a point for which the latitude is 5 ($x=5$) and the longitude 4 ($y=4$). Then this equation tells us that y' must be 9; in other words, it tells us that we should travel away from this point in the "direction 9", whatever that may mean.*

Suppose we obey the command and start out in this direction. Our latitude and longitude immediately change; that is, the x and y which must be substituted in equation (2) are no longer 5 and 4, but are somewhat different and therefore give a somewhat different direction y'. Let us change our direction to conform to this new command and proceed. Again our latitude and longitude change and because they have changed the command given by equation (2) also changes. We can imagine ourselves, however, traveling in a constantly changing direction in such a way that at all times we instantaneously obey the command of equation (2). If we do this we shall follow a curved path which is said, in mathematical language, to "obey the differential equation (2)".

It is obvious then that equation (2) has done for this curve exactly what the lawyers did for the boundary of my lot; it has told us in what direction we must travel in order to follow along a certain curve.

Shifting our point of view somewhat, it may be interesting to think of ourselves taking various positions in the plane, and nothing that equa-

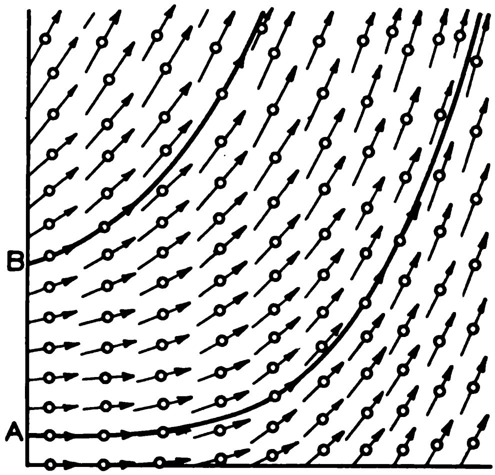


Figure 1

tion (2) assigns to each of these points a definite direction. If we were to take up position after position, we might note the direction in which we were commanded to proceed, and lay down an arrow to indicate it, thus producing an array of arrows somewhat like those shown in Figure 1.

In looking at this figure each arrow tends to carry the eye to the arrow next ahead of it, in such a way as to associate the arrows into groups. By beginning at any point A and connecting the arrows of such a group together, a curve is produced which has, at each of the points to which arrows are affixed, the direction required by (2).

If the number of arrows is greatly increased the number of points at which the curve satisfies (2) is also greatly increased. In fact, by making

* *What it means is that we should travel in such a direction that the longitude changes nine times as fast as the latitude.*

the arrows more and more numerous it is possible, in theory at least, to approach a limiting curve, the direction of which satisfies the differential equation at every point. It is, in other words, the path along which we have imagined ourselves to have walked.

If, however, we were to start from a different point B, a different curve would be obtained. Obviously this new curve, like the old one, obeys (2); both are therefore "solutions" of it. We could find many other such curves by starting from still other points. It follows, then, that a differential equation defines, not one curve, but many. Indeed, we could show that their number is infinite.

We have now been led to the two most fundamental facts about differential equations: that they define, not curves, but families of curves; and that they define them by telling, not positions of points, but directions of advance. To sort out a single one of these curves it is necessary to specify a point of beginning, or "boundary value", just as, in describing the boundary of my lot, it was necessary to say "Begin at the marble monument". Had these words been omitted my home might be in California or Timbuktu, so far as anyone could determine from the deed.



NEW YORK TALKS WITH PARIS

Those pictured at the New York end of the circuit are: A. W. Page and C. P. Cooper, Vice-presidents of the American Telephone and Telegraph Company; W. Wilson of the Laboratories; Bancroft Gherardi, Vice-president, A. T. & T.; R. A. Heising, John Mills and R. H. Wilson of the Laboratories; President Gifford; H. D. Arnold, B. W. Kendall and H. W. Everitt, of the Laboratories; John J. Carty, Vice-president, and E. H. Colpitts, Assistant Vice-president of A. T. & T.; B. B. Webb and A. M. Curtis of the Laboratories; F. B. Jewett, Vice-president, A. T. & T. and President of the Laboratories; T. G. Miller, General Manager, Long Lines; O. E. Buckley of the Laboratories, and E. B. Craft, Executive Vice-president of the Laboratories

Telephone Service Opened with Paris

INAUGURATING telephone service between the United States and France, a group of telephone executives and engineers on March 28 gathered at 195 Broadway, New York, and talked with another group in Paris. Reminiscent of the first radio-telephone transmission to Paris in 1915, twelve of the men concerned were present in New York and one was in Paris.

Conversations took place between President Gifford and M. Maurice Bukonowski, Minister of Commerce and Industry for France; between Mr. Gifford and General Pershing, then in Paris; between General Carty and M. H. Milon, Chief Engineer and Director of Telephones, Ministry of Posts and Telegraphs; between General Carty and H. E. Shreeve, and between B. B. Webb and Mr. Shreeve. In 1915; Mr. Webb was one of the talkers at Arlington, and Mr. Shreeve a listener at Paris; one of the first phrases to be understood in 1915 — "and now, Shreeve, good night" — was part of their 1928 conversation.



Group at the Paris terminal

In every respect, the occasion presented wide contrast to the demonstration of 1915. Instead of trying day after day to get a few words across, and being baffled over and over by interference and static, the two groups gathered at a prearranged time with well-justified confidence that their conversations would proceed without a hitch. Nor was there a delay of two days to learn by cable that Paris had understood New York; the immediate response by telephone left no doubt of the intelligibility of both transmissions.

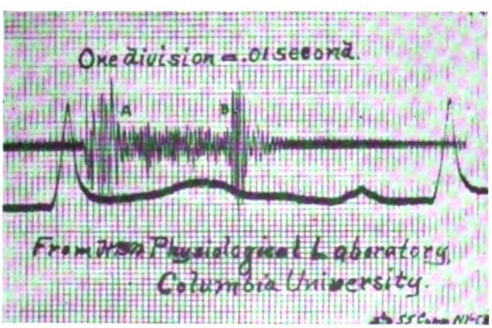
The circuits used last month were those of the regular transatlantic radio system between New York and London. At London connection was made with cable circuits recently constructed both overland and across the Channel.

Telephone service is available between American subscribers in general, and subscribers throughout Great Britain as well as in Paris and in fourteen principal cities of continental Europe. Thus the American telephone subscriber has at his elbow not only the eighteen million telephones connected to the Bell System, but 1,385,000 telephones in adjacent countries of North America and three million telephones in Europe.

Phonograph Records of Heart Sounds

By D. G. BLATTNER
Research Department

WITH the development of the electrical stethoscope* we took great pride in the fact that the most skillful physician was brought to the bedside of the most isolated patient. A striking demonstration of this was the telephotic transmission of a stethogram of a New York patient to Dr. Greer in Chicago, who correctly diagnosed the case and prescribed the proper treatment to the American Medical Association in convention in Atlantic City. Having already annihilated the lesser distances which separated the collective ears of a medical class



Combined stethogram and electrocardiogram sent by telephotography from New York to Dr. Greer in Chicago

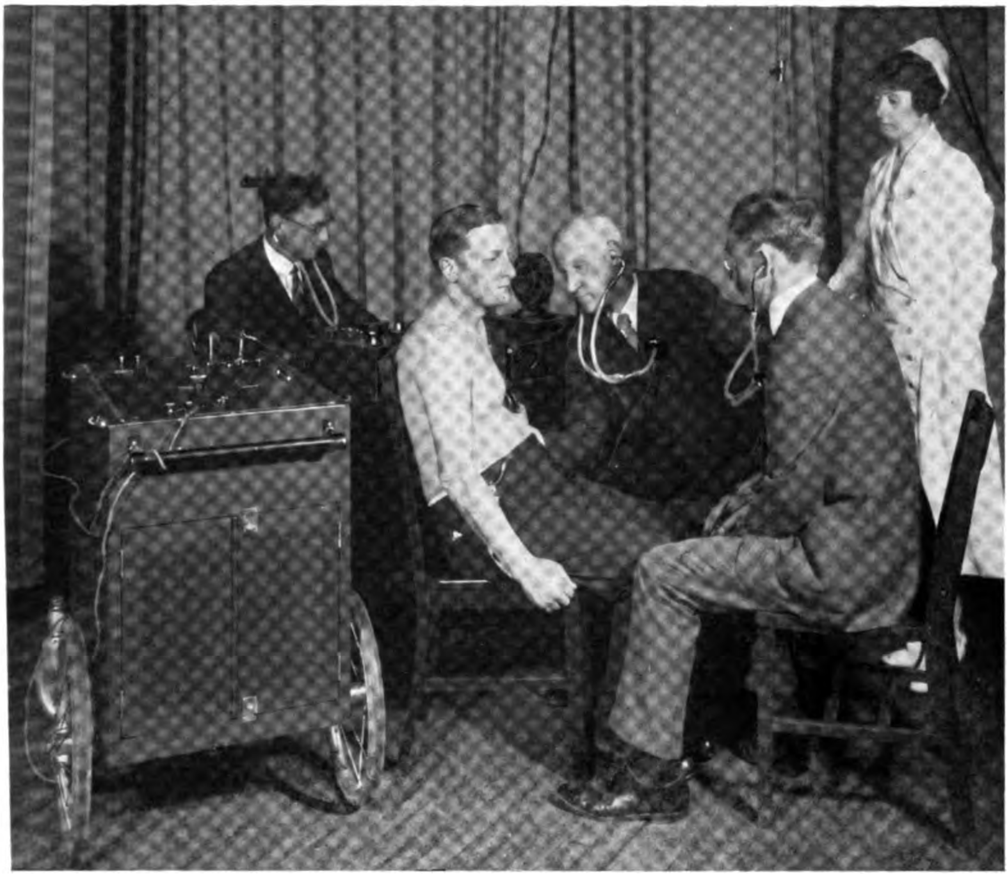
from the patient's chest — the original purpose of the electrical stethoscope — our attention turned to the annihilation of time as well, so that both student and practitioner might auscultate a patient whose case history had long since been closed. Dr. Cabot, Dr. Gamble, the Columbia Phonograph Company, and Bell Telephone Laboratories in cooperation began experimenting with the recording of various types of abnormal heart sounds* by means of the electrical stethoscope. Now, after two years of effort, a library of a dozen or so records of the more usual types of abnormalities are being released for sale through the Columbia Phonograph Company.

His heart sounds having once been recorded, a patient may be spared even the slight fatigue of further examination for instruction purposes. More important, however, is the fact that clinical patients of every type of abnormality are not always available, so that in the past the instruction of many student physicians has been incomplete. Now not only can the instruction be more complete in regard to types of abnormality but also it can be arranged in such a way as to produce the most definite and lasting impressions.

While heart sounds were recorded on phonograph records two years ago, satisfactory reproduction from the records at that time was possible only through the use of apparatus that was costly and not widely available. Commercial phonographs would not reproduce the important low-frequency vibrations in the heart sounds, so that an electrical repro-

* Bell Laboratories Record, *Oct.*, 1925, *p.* 41.

* Bell Laboratories Record, *Dec.*, 1925, *p.* 162.



Recording the heart-sounds of a patient. Comments of the physician are recorded at the same time by means of the microphone

ducer had to be used. There was no objection to this apparatus from the standpoint of reproduction, but the electrical system with its vacuum tubes and filters was and is far too expensive for any very widespread use. In order that students and physicians all over the country could take advantage of the phonograph records of heart sounds some simple device was necessary.

This meant that a special pick-up device must be developed having suitable characteristics and yet of small enough cost so that one could be included with each group of records sold. Other requirements, aside from cost, availability, and faithfulness of reproduction, were that it must be relatively free from surface noise incidental to dragging a needle through the groove of a phonograph record. Also, the sound should pass to the ear of the user through an acoustic stethoscope so as to duplicate the tone quality that he may be accustomed to hearing in practice. The final form developed to meet these requirements is shown in the accompanying photograph. Since the heart sounds are largely of the nature of transients it is necessary that the pick-up be heavily damped if not aperiodic. This is accomplished by

means of a rubber diaphragm and by the damping action of the finger-tips which serve as the pivot of the needle arm.

In using the device the listener places one of the records on any phonograph turntable available, attaches the pick-up device to the ear-pieces of his acoustic stethoscope and holds it to the part of the record that may be of interest to him. Such volume adjustment as is necessary is obtained by means of the adjustable clamp shown in the picture.

While the group of records now available covers the more usual types of abnormalities of the heart it is in a sense still very incomplete. Who, for instance, can estimate the importance of having a record of the sound of a normal human heart between the periods of the cradle and the grave? or of the progressive development of a particular case of abnormality? Of what importance might not records, covering a period of time, be in determining the effectiveness of different forms of treatment for a given type of abnormality? It is probable that in years to come records of these and other sounds will be found as a regular part of each physician's library.



A student listening to heart-sounds by means of the pick-up device

Amplification Behind the Talking Movies

By H. A. DAHL
Apparatus Development Department

MUSICAL accompaniment synchronized with motion pictures but without an orchestra in the theatre was made possible a few years ago by developments in Bell Telephone Laboratories. Success greeted the first demonstration of this achievement and since then its use has become more widespread every year. The first commercial development used a disc phonograph record rotated in synchronism with the film passing through the picture-projection machine. Music picked up from the record with ordinary acoustical apparatus would not have sufficient volume to fill a theatre, so an electrical reproducer is used which enables an amplifier between it and the loud speakers to increase the feeble reproducer currents to values that will produce a volume of sound equivalent to an actual accompanying orchestra. In another development the music is recorded on a film which is run through reproducing apparatus also operated in synchronism with the picture projector, but here too the reproduction is electrical and requires considerable amplification.

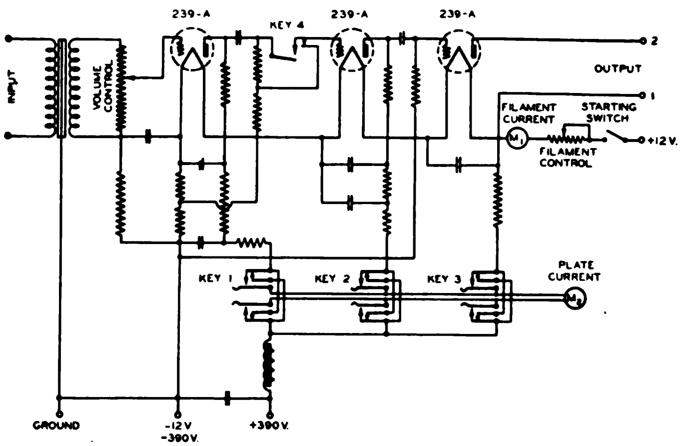
Apparatus required for this amplification is one of the major parts of the equipment. The early installations used amplifiers which were available at the time and although designed for other purposes would give satisfactory amplification. Subsequent improvement in amplifying technique, however, has made improvements possible, particularly by eliminating the rather extensive batteries required by the older amplifiers, which are objectionable from the standpoint of maintenance in commercial theatre installations.

With the object of producing equipment which embodied exactly the features required for this service a new amplifier system was designed. This is made in units so that a suitable selection of the units may be made to obtain the proper volume of sound for the different sizes of theatres to be accommodated. These amplifiers, shown mounted on a rack in the accompanying photograph, are the 41-A, 42-A and 43-A. Power supplies required for their operation are of the simplest possible type. Only a small capacity twelve-volt battery and a 110-volt alternating current supply are necessary.

Over one-half the total amplification of the system is produced by the 41-A amplifier which raises the energy level of the reproducer to a volume suitable for the operation of a power amplifier. Essentially it is a three-stage resistance-coupled circuit using 239-A tubes in each stage.

In any high-amplification system such as this, the vacuum-tubes in the first and second stages are very sensitive to external disturbances. Slight jars or knocks or even air currents impinging on the tubes are converted into electrical impulses which are carried through the amplifier to the loud speakers, where they appear as

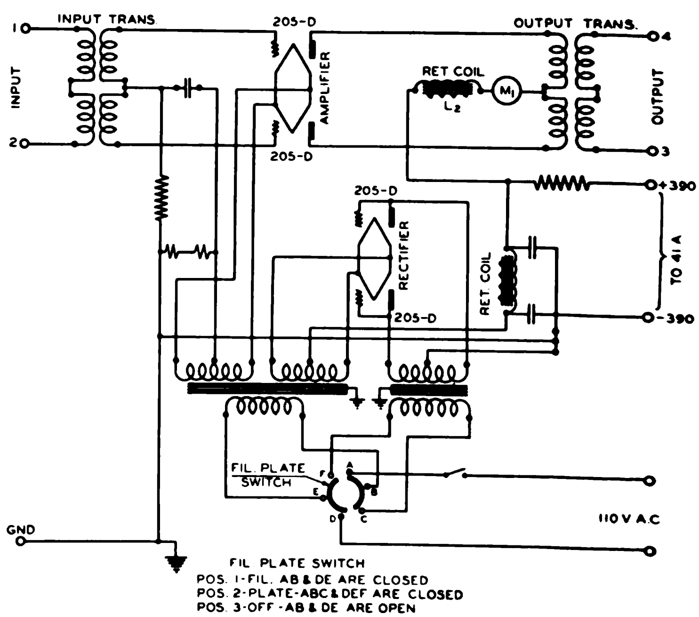
grating sounds. In the 41-A amplifier special precautions are taken to prevent this. The three vacuum-tube sockets are each mounted on a separate piece of sponge rubber which is fastened to a heavy steel plate. This plate in turn is suspended on sponge rubber mountings. The method of suspension here employed, which is called the inertia type, was evolved after an extensive series of tests. The sponge rubber beneath each tube socket prevents the higher frequency disturbances from reaching the tube, and the heavy plate suspension, because of its inertia, filters out the lower frequency disturbances.



Schematic of 41-A Amplifier

The filaments of the three tubes, which require a quarter of an ampere current, are connected in series and supplied by a twelve-volt battery. Plate potential is obtained from the 42-A amplifier at 390 volts which is reduced by resistances in the plate circuit of each stage so that in no case is more than one hundred volts applied to the plate. In conjunction with these resistances are condensers which act as filters to smooth out more perfectly for these sensitive first stages the rectified plate supply from the 42-A amplifier.

A key turns off or on the filament current and a rheostat allows adjustment of the current strength which is read on the milliammeter provided. Plate current for each stage may be determined by pushing a key associated with each



Schematic of 42-A Amplifier

tube, which connects a second milliammeter into the circuit. Two volume controls are provided. The dial in the upper left-hand corner of the panel affords a control of sixty-six TU in steps of three TU each, and a key located beneath the vacuum-tube cover, marked Key 4 on the diagram, can be set to produce an attenuation of fourteen TU.

The 42-A amplifier is a single-stage push-pull power circuit employing 205-D vacuum-tubes. It is operated entirely from an alternating current source and consumes about eighty watts. Four vacuum-tubes are used: two as amplifiers, and two as rectifiers for the plate potential of four hundred volts. The only control provided on this amplifier is a snap switch for connecting the alternating current supply. In starting, this switch is turned to the first position which lights the filaments only. After they have had time to warm up, the switch is advanced to the next position which places the amplifier in operation by applying potential to the plates. This procedure reduces the strain on the vacuum tubes which would occur if the high voltage were applied while the filaments were still cold.

The 41-A unit gives an amplification of one hundred times or forty TU, and the 42-A of eighteen times or twenty-five TU additional. The latter has sufficient capacity to serve as the final power amplifier where the location requires only a moderate volume. Where greater volumes are found necessary they may be obtained by using two 42-A units in parallel or by adding the third unit of the series, called the 43-A.

This last unit of the series is also a single stage push-pull power amplifier, but uses 211-E tubes. It also is operated entirely by alternating current and consumes about three hundred watts. Its circuit is similar to the 42-A except that 211-E tubes are used with a plate potential of eight hundred volts. Behind the sheet metal container on the front



41-A, 42-A, and 43-A Amplifiers mounted on a rack

of the panel are the filter condensers connected in the rectifier circuit. They may be examined and repaired by removing the hinged cover.

This unit produces an amplification of six times or fifteen TU, which makes the three units combined yield an amplification of ten thousand times or eighty TU. The 43-A amplifier has sufficient capacity for locations where considerable volume is required. To obtain even greater volumes for distribution through very large theatres two of the 43-A amplifiers may be used in parallel.

In the Vitaphone system the input terminals of the 41-A amplifier are connected to a "fader" which is used to transfer the amplifier system from one reproducer to another at the end of each record. Two projection machines are operated side by side so that while the record used with one is being changed, the other is in use. The output terminals of the last amplifier unit are connected to a receiver control panel which permits a selection of the receiver desired and also permits the volume of each to be adjusted. The complete assembly on the rack as shown makes a convenient and easily operated outfit.

Communication: A Force in Intellectual Evolution

The intellectual evolution of the individual may have come to an end but whether or not this is true, it is certain that the intellectual evolution of groups of individuals is only at the beginning. Progress along this pathway is vitally dependent upon the work of the engineer, for the perfection of all forms of communications and transportation is essential in order that this new superorganism, human society, shall achieve its destiny.

The use of the spoken word to convey ideas distinguishes man from all other created things. It is the function of the engineer to provide for the extension of the spoken word by means of electrical systems, serving to connect the nervous system of each unit of society with all of the others, thus providing an indispensable element in the structure of that inconceivably great and powerful organism which it is believed will be the ultimate outcome of the marvelous evolution society is to undergo.

The ideals of the engineer will not be realized until man has achieved his destiny in that social organism which is foreshadowed "with its million-minded knowledge and power to which no barrier will be insurmountable, no gulf impassable, and no task too great."

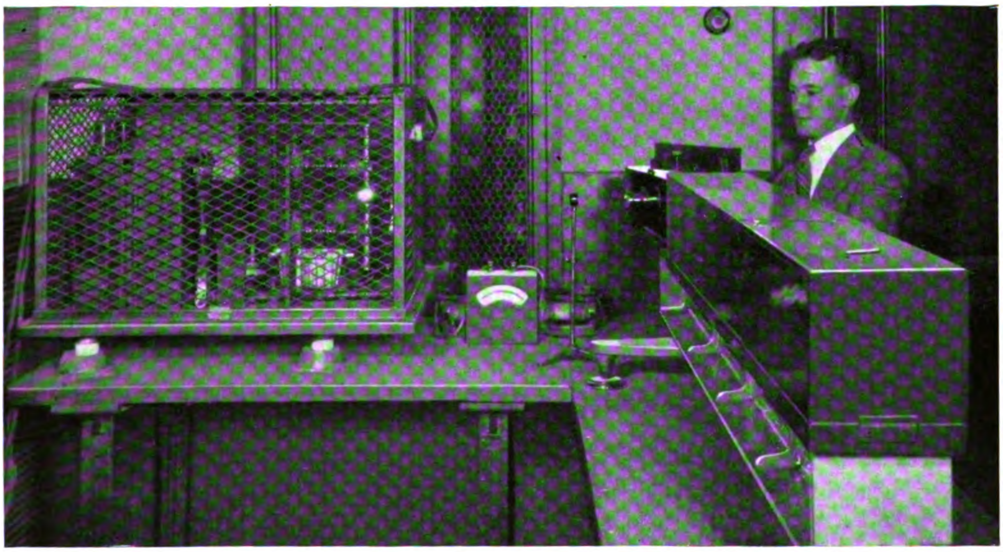
—From an address delivered by Gen. John J. Carty upon receiving the John Fritz Medal.

Spectrographic Analysis

By EARLE E. SCHUMACHER
Research Departmemt

CHEMICAL analyses both qualitative and quantitative are required daily of the Chemical Department of Bell Telephone Laboratories. Standard methods in some cases are slow, difficult, and costly, particularly when applied to the determination of impurities present in small amounts. A shorter method is available, however, as it has been satisfactorily demonstrated in recent years that many of the more difficult analyses can quite easily be made spectrographically. This method is frequently used therefore, and for such work the Laboratories are equipped with a Hilger Quartz Spectrograph, shown in the illustration.

When an electric spark passes between two electrodes the intense heat developed vaporizes and brings to incandescence a small amount of the electrode material. If the electrodes were composed of a single element the radiations would contain only a limited group of wave lengths characteristic of that element. In this respect the spark radiation differs from that of the sun which contains all wave lengths. On this individuality of radiation of each element spectrographic analysis is based.



A. H. Staud in charge of the quartz spectrograph taking a spectrogram. Light from the arc on the left passes through the focussing lens onto the slit through which it passes to be reflected at right angles toward the front end of box. Here is mounted the prism which spreads out the spectrum and reflects it back to the photographic plate projecting above the case at an angle in the rear

Substances to be identified are ionized in the electric spark and their light, after passing through an optical system consisting of lenses and a prism, is finally photographed. In passing through the prism the light waves are bent through angles dependent upon their individual wave lengths and are recorded on a sensitized plate as a series of bright lines. The relative position of each line corresponds to the wave length of the ray producing it and thus each element produces a spectrogram showing a definite and individual set of lines. Distances between spectral lines are measured with a comparator, a precise instrument that enables the position of all the sensitive lines shown in a spectrogram to be compared to those of any known element merely by making the required micrometer settings.

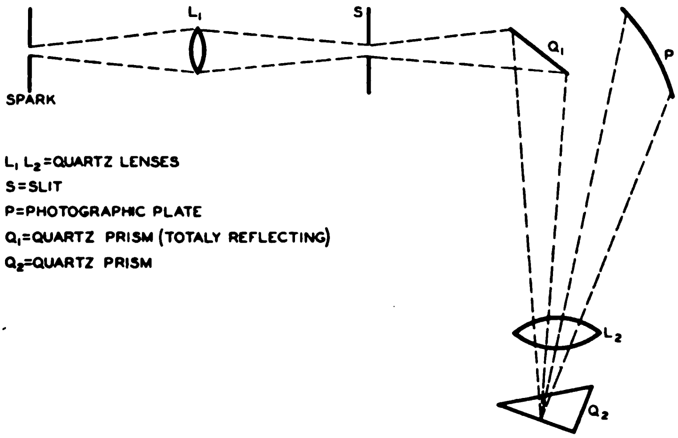


Fig. 1—*Diagram of the Hilger Quartz Spectrograph*

Since the most sensitive spectral lines for the majority of the elements are located in the ultra violet region the optical system is made of quartz which is transparent to these radiations, instead of glass which is opaque to them. The electrodes are generally made of the sample to be analyzed; but when a case arises where this is not possible, graphite electrodes impregnated with the unknown material are used.

If the presence or absence of any element in a test sample is to be determined, spectrograms of the sample and of the element sought are photographed side by side. After the plate has been developed the results are obvious. If the spectral lines of the known element continue through the spectrogram of the sample, the presence of that element is established.

An accompanying illustration shows the application of this scheme to an unknown alloy which was thought to be composed of copper and gold. The spectra of copper, gold, and the unknown were taken in juxtaposition with the spectrum of the unknown placed between the other two. It can be readily seen that the lines of the copper and gold spectra also appear in the spectrum of the unknown which proves conclusively the presence of these two elements.

Among the practical qualitative applications of spectrographic analysis is the identification of the elements in a material when only a small amount is available. All large concerns are continually receiving small samples of materials bearing queer names such as dreamium, dubium, or miraculum. These materials are supposed to have certain remarkable properties upon which the inventor has high hopes of capitalizing. With-

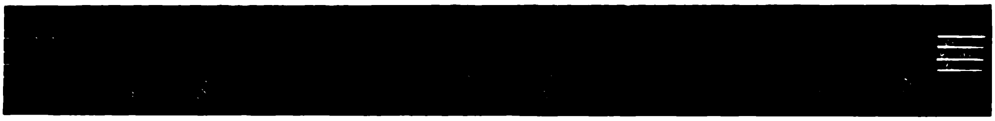


Fig. 2—Spectrogram of copper (at top), gold (at bottom), and an unknown alloy of copper and gold between them

out undue exertion or expense a spectrogram will usually tell quickly if the material is something new or simply an old model newly labelled.

Another application is the identification of the elements in a valuable specimen without destroying it. The specimen itself is used as an electrode and the momentary spark necessary to make the spectrogram does not vaporize an appreciable part. Where alloys of different composition but similar appearance are handled in the same stockroom the supplies occasionally become mixed. Spectrographic analysis is particularly applicable in such a situation as it offers a rapid and simple method of identification.

Quantitative analysis is also possible to a certain extent with the spectrograph because up to a given percentage, different for each element, the intensities of the characteristic lines of an element are proportional to the relative amount of it in the substances. If one element occurs in another as a slight impurity only, none but the most sensitive characteristic lines of the impurity will appear in the spectrum. As the amount of the impurity increases new and less sensitive lines appear and the old lines become more intense until the whole spectrum is visible. Generally impurities ranging from .003% to 1.0% of the whole can be determined quantitatively by this method. The procedure is to photograph the unknown on the same plate with a graded series of knowns. With a microphotometer to measure the relative brightness of the lines, the unknown can be easily placed.

Figure 3 shows the spectra of a graded series of lead-tin alloys containing from 0.0 to 1.97% antimony. As the antimony content increases the antimony lines are seen to become more intense. With a microphotometer, any unknown quantity of antimony in lead varying from 0.0 to 1.97% can be readily determined by comparing the spectrogram of the unknown with those of the graded series.

Spectrographic analysis is extraordinarily sensitive; authorities state that quantities as small as one three-

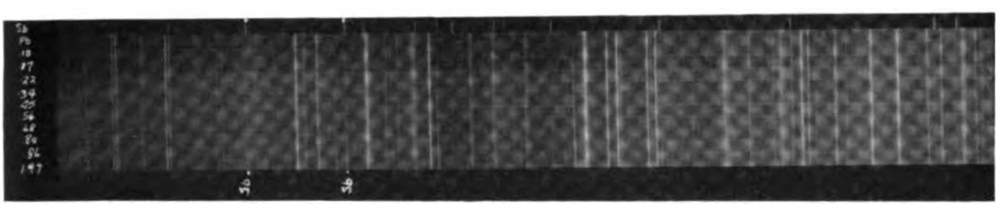


Fig. 3—Spectrogram of a graded series of lead-antimony alloys containing increasing amounts of antimony (given in percent at the left). The spectra of antimony and lead were taken as references. The two most sensitive antimony lines are marked

millionth of a milligram of sodium, one one-hundred-thousandth of a milligram of lithium, or six one-hundred-thousandths of a milligram of strontium or calcium can be easily detected. Practical quantitative applications of the spectrograph include the determinations of small quantities of almost all the elements. It is an interesting fact that the spectrographic method becomes more precise as the proportion of test element decreases, while the wet analytical method becomes less precise.

The Laboratories Take to the Air

WITH the delivery of an airplane and the addition of a pilot, to its staff, the Laboratories have taken two definite steps in the recently-announced program of radio development for aviation. The plane is a cabin monoplane built by the Fairchild Airplane Manufacturing Corporation; the pilot is A. R. Brooks, formerly a captain in the Air Service.

Taking form in a broad study of radio transmission between ground and planes, the field investigation will first concern itself with the effectiveness of various types of antennas, and with the effect on transmission of the plane's height above ground. In this work, the Laboratories' experimental station at Whippany, New Jersey, will be used for transmission. Development in the laboratory is already well advanced on the necessary transmitting and receiving apparatus and tests in the air will shortly begin. The experimental work will be carried on by the radio development group, under the leadership of E. L. Nelson.



A. R. Brooks, pilot of the Laboratories' plane

Since aids to navigation are an outstanding need of commercial aviation, one of the problems to receive early attention will be the development of a system by which the pilot can determine his bearing from various points on the ground. Means for the transmission of weather bulletins and other information to planes will also be developed.

The plane is one designed to accomodate five persons. The seats for passengers have been omitted, and in this space will be installed receiving apparatus and a field-strength measuring set. The electrical system of the plane will be carefully shielded to avoid interference from the engine's ignition circuits. Lamps and flares



The Fairchild plane to be used by the Laboratories for aerial communication research

have been provided to permit night flying. Initially, the plane will be based at Hadley Field, where hangar and laboratory space has been engaged. This is within a few minutes by air of the laboratory at Whippany.

Captain A. R. Brooks, the first man to be engaged by the Laboratories as an aviator, has had a distinguished career in the United States Army. Graduating from Massachusetts Institute of Technology in 1917, he was about to enter these Laboratories when the World War claimed him. During his service in France, Captain Brooks was officially credited with destruction of six enemy planes. He is the holder of the D.S.C. and of several citations. Since the Armistice he has been identified with military instruction in aeronautics, and with commercial aviation.

There are now available for members of the Laboratories sets of personal financial records in booklet form. These records supplement the A. T. & T. income and expense record which has been available to members of the organization for some years. They are especially intended for those who do not keep a detailed expense account, but who wish to determine their financial status at intervals. Copies of these records may be obtained by applying to the Employee Service Department, Section 1-H, Extension 435.

Rotary File Type Information Desk

By V. I. CRUSER
Systems Development Department

YOUR chief concern as you hold the receiver to your ear after having asked for "Information" is that you find out what you want to know as quickly as possible. Probably you do not give a thought to the facilities that must be available to enable the operator to give the information with the least possible delay. Until the new Information desk, briefly referred to as the Number 2, had been designed operators at information desks used books much like the larger city directories, which were kept in a book rack upon the desk top, and in which were printed the latest addresses and telephone numbers of the subscribers. Due to the rapid growth of telephone service in recent years, it became necessary in the larger cities to print daily supplements and to reissue the entire book frequently in order to have it up-to-date. Studies indicated that to keep records in rotary type files would overcome a number of the difficulties previously encountered excepting in the very largest cities.

Each section of the No. 2 Desk is arranged for a single operator. The front part of the keyshelf is a narrow writing space; behind this are the trunk keys, depressed in a trough to prevent accidental operation. Each keyshelf is arranged for fifty-two trunks incoming from various central offices through which the inquiring subscribers may be connected to "Information." A signal lamp and a listening key are provided for each trunk by which the operator may know when a call is on the trunk and connect her headset into the circuit. The same set of fifty-two trunks are connected in multiple to several positions; if traffic is heavy as many as eight operators may be required, while late at night or at other times when traffic is light, all but one or two operators for each set of trunks may be excused.

Just in the rear of the keyshelf, within easy reach of the operator, a rotary file is placed on each section. The section was designed for a file approximately thirty inches in diameter and twenty-six inches high. A file of this size has a capacity, somewhat dependent on its make, of approximately 75,000 listings, but in a district of a large city served by a centralized information desk there may be as many

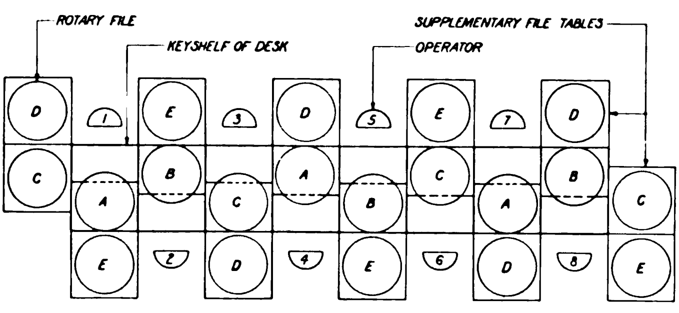
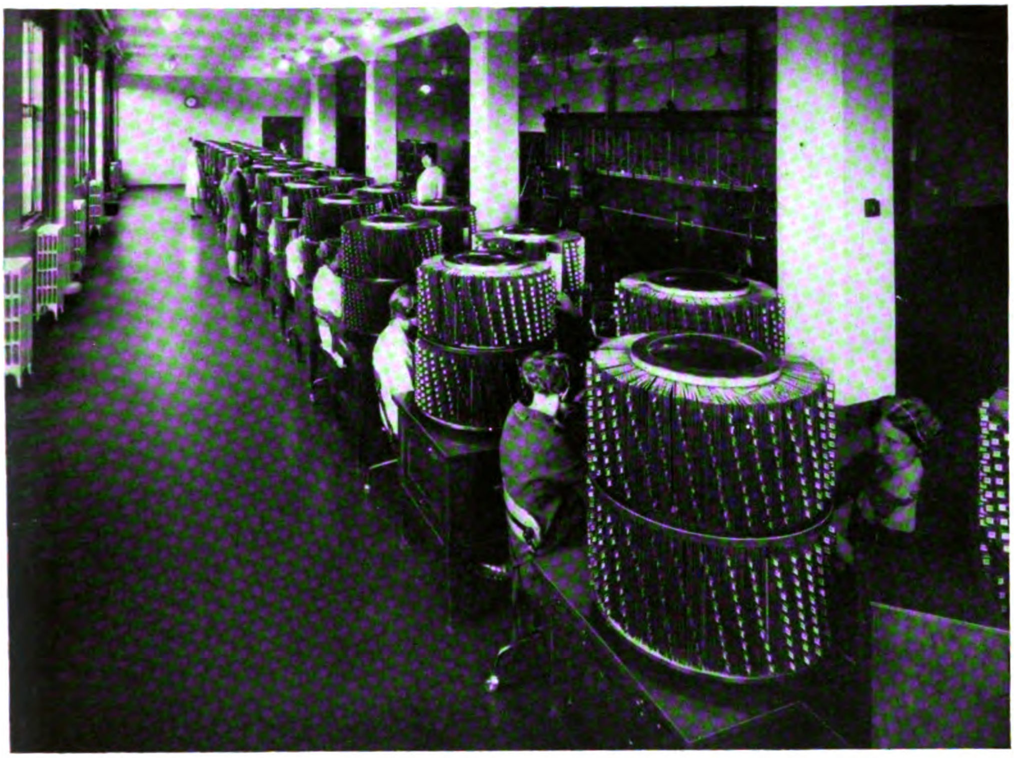


Fig. 1—Floor plan whereby each operator can reach five files



The new information bureau at Cleveland

as 200,000 or even 300,000 subscribers. Since it was considered essential to have all listings before each operator, some way had to be devised to give each operator access to several files. The result was the so called "staggered" line-up. The positions are arranged side by side but alternately facing opposite directions. The key-shelf of each section is indented slightly between the rear of the two adjacent positions. In this way each operator has three files of the rotary type within easy reach: one on her own section in front of her, and one on each side of her on the adjacent sections. A glance at the photograph of Cleveland's new information bureau will help to give a clear picture of the arrangement.

Names, addresses, and telephone numbers of the subscribers are printed on cards which slide in the many radial leaves of the rotary file. A space 1/6″ wide and about 5″ long is provided for each subscriber. It is evident that, since one file is common to three operators, more than one of them may wish to use the same file at a time. In order to reduce the liability of interference double-tier files are used. They are made with two circular frames for the leaves, one above the other, each rotating independently so that one operator may use the upper part while another uses the lower part without interference.

When more than three files are required for the information cards, rotary files on a supplementary table placed at the rear of each desk afford the operator access to two additional files. At Cleveland only the three file arrangement is used but the floor



"Information" getting the information

plan shown as Figure 1 illustrates the five-file arrangement.

Since subscribers' addresses are ever changing, and since the information bureau is the one place which must have the new addresses almost before the telephones have been connected, some rapid means is required to furnish the information in a form for the files. To accomplish this an attachment is supplied for use with an ordinary typewriter which, in place of typing on paper, prepares a stencil of thin sheet aluminum. These stencils, in turn, are used with a simple duplicating machine to produce any desired number of clean-cut prints on file cards. The machines are easily operated and a typist with no special ability can have the new address of a subscriber in all files a few minutes after the information is received.

Each group of eight operators at the Number 2 Information Desk is placed directly under the jurisdiction of a supervisor whose duty it is to see that all requests for information are dispatched efficiently and to answer any calls of a complex nature which would take up too much of an operator's time to complete. Provision is made so that the supervisor may be called, both by a bell and a visible signal, to any of the operators who wish to ask her a question or to have her complete a call personally. The supervisor's circuit is so arranged that after she has picked up a call by plugging into a set of jacks, the operator who originally answered the call is free to handle any other unanswered calls.

Because of the fact that a great many of the incoming calls are for information other than that which the operators are equipped to give, the supervisor is kept particularly busy. She may be asked whether Mrs. Brown has moved into her new home, or what is the telephone number of the man who lives opposite Mr. Smith? Many queries such as these she may not be able to answer, but in any case she must make sure that the subscriber puts the receiver on the hook without dissatisfaction.

Another feature has been incorporated in this new desk which is of general interest. There are always apt to be moments when calls come into the information desk faster than the operators there can handle them. As each call arrives a signal lamp lights but if several calls have come in while the operators are busy there is no way of distinguishing those that came in first, and should for that reason have attention first.

To avoid this difficulty and to make sure that each call will be given attention in the proper order a flashing circuit has been developed which flashes the signal lamp to show that the call has been waiting. When the call first comes in the signal lamp burns steadily. After a short interval, the duration of which is adjustable, the lamp starts flashing at the rate of sixty flashes per minute.

The next time you ask for "Information, please" try to visualize what is taking place at the information desk. See the operator catch a glimpse of a lighted trunk lamp, see her flip the trunk key so that she may tell you that she is ready to help you; see her twirl one of the files around, pick the particular leaf, spread the leaves at that point, and run her finger up to the name of the particular person whose number you want —all this in a few seconds.

Does Business Want Scholars?

Writing under this title in Harper's Magazine for May, Walter S. Gifford discusses the results of a study of the correlation between scholastic attainments and business success. College records of some 3800 graduates within the Bell System were compared with their subsequent business records and it was found that scholastic success in college showed a marked correlation with later success in the Bell System. For instance, of those in the first tenth as to salary, seventeen per cent came from the highest tenth of their classes, while only four and one-half per cent came from the lowest third. The article has received a number of favorable comments in newspapers.

Life Insurance Protection

By J. F. MORAVEC
Commercial Manager and General Auditor

A RECENT conversation with a member of the Laboratories brought to light this story of one man's experience.

"Less than a year ago I purchased a home in which my equity is rather small. A goodly part of my mortgage is payable over a period of about seven years and this had me considerably worried. Of course, I can meet the obligations as they become due, if I stay on the job; but I worried because, should I die, my wife and the children would be burdened with a debt of large proportions with no means of liquidating it. I had given some thought to additional life insurance, for I carry only a little, but dismissed that idea because of the cost which I felt I couldn't afford.

"With the introduction of the Payroll Deduction Plan for insurance, the salary deduction feature appealed to me and I arranged to see Mr. Bunting about my problem, but with no great hope of finding a solution. Imagine my agreeable surprise, therefore, when I learned through him of a form of policy just suiting my case and costing comparatively little for the protection offered. This is a special 'term policy' for the period of my mortgage which decreases in principal as well as in premiums as I make payments on the mortgage. I have that policy and worry no more. Should I drop off during the next seven years, my family will obtain the free and clear title to our house.

"I am getting on in years and am now trying to do what should have been done earlier, that is, get together some little estate for my family. I feel confident that if the plan for insurance which is offered us today, with the opportunity of free and intelligent discussion of the various forms of protection and with its easy payment features, had been available to me 23 years ago when I first joined the Company, (and that is on the supposition that I would have been foresighted enough to subscribe to it) I would now have sufficient protection for my family at considerably less cost and with very much less worry.

"Another thing, — it is only within the last few years that I have come to fully appreciate the advantages to me of the A. T. & T. Stock Plan. While I have always subscribed for a few shares, I sold them for profit and now have neither profit nor savings to show. I am now subscribing to the limit permitted under the plan and later this year when my present shares are fully paid for, the certificate will go at once to my strong box. At the same time, a new subscription for my limit will be filed. Had I done that from the beginning, I would be 'sitting pretty' now."

These are the views of one of our associates, who after a discussion of several business matters drifted into

a general discussion of the thrift plans made available to us.

It is unnecessary to point out the moral in the foregoing. It is, however, a story worth repeating, for it illustrates the adaptability of life insurance to individual needs.

From numerous comments that have come to me, it would seem that most of us agree that life insurance takes first place in, and is an indispensable part of, our individual thrift programs. If that is true, have we taken steps to make it effective? Have we given thought to and have we selected the kind of insurance that best meets our requirements? Many factors enter into the making of this decision. Such considerations as marital status, age, amount we can spend on premiums, amount of insurance wanted and whether we want insurance for protection or primarily for investment are all important. To help us in these considerations, Mr. Bunting who is an expert in such matters is always available for consultation and advice in selecting the kind of policy which will "fill the bill."

If we are looking primarily for protection, the type of policy best adapted to the needs of most of us is "ordinary life." While "term insurance" is the cheapest protection that can be bought, it should be bought only in unusual cases where for a brief period it is essential to obtain the maximum protection at minimum outlay. Term insurance does not provide permanent protection but automatically expires at the end of a limited period unless converted into some form of permanent insurance. Premium payments on term insurance do not build up a reserve cash value as under permanent policies, and if converted the advantage of original age is lost as the premiums on the permanent insurance will be based on age at the time of conversion.

Thus, where permanent protection at the lowest premium rate is wanted, the ordinary life policy seems best. This is often referred to as "whole life" or "straight life" insurance because it provides for payment of the full face amount upon the death of the insured in exchange for uniform premiums throughout life. It also combines a considerable amount of saving, since after the first year the policy has a cash value, increasing from year to year, which the insurance company will lend to the insured at interest or pay to him if the policy is cancelled. If one wishes to avoid payment of premiums throughout life, dividends may be allowed to accumulate with the insurance company, thus producing a fully paid up policy in about twenty-one years. Of course, payment of face amount is still deferred until death; but premium payments are no longer made and yearly dividends continue to accrue and may be withdrawn in cash.

Of numerous special features which have been added to life insurance policies in recent years, none, perhaps, is more deserving of mention than the provision of disability benefits. For a small additional charge, the insurance company, in case of disability before age 60, will pay disability benefits at the rate of ten dollars a month for each one thousand dollars of insurance and will waive all premium payments during such disability. Payments for disability leave unimpaired the death claims of the policy plus any accumulated and unpaid dividends. Many persons become disabled for a considerable period pre-

ceding death. So far as the family budget is concerned, a protracted illness resulting in death is more serious than the sudden demise of the breadwinner. In many instances lingering disease renders the insured incapable of earning anything for many months, sometimes for several years. During this time heavy expenses are often incurred for professional services, and in other ways. We are quite apt to think that no such catastrophe will overcome us. But should we take the chance? The disability clause added to an ordinary life policy may prove to be of inestimable value.

Ordinary life contracts are also written, upon payment of a small additional charge, to provide death benefits of double the face amount of the policy in case death results from bodily injury. This is a desirable feature at small cost, particularly in cases where no accident insurance is carried.

For those of us who wish to be relieved of premium payments after attaining a certain age, probably the limited payment type of policy will have a greater appeal. This type of policy is identical with the ordinary life policy except that instead of paying premiums for life, one pays them for a limited period of 10, 15, 20, 25 or 30 years. At the end of the specified period, the policy becomes paid up for its full face value and continues to share in dividend distribution. For the longer periods, the limited payment policy is not much more expensive than the straight life and is well worth considering for those who can afford to pay a little more per year. Without sacrificing protection during one's productive years, it affords one means of accumulating an income-producing investment for the later years of life.

In all the foregoing, I have only scratched the surface of a subject which deserves the careful consideration and study of everyone. There are many points which I have not covered at all, and many which I have barely mentioned. However, we have with us Mr. Lloyd H. Bunting who is eminently fitted to assist us in working out our insurance problems. Mr. Bunting is the authorized agent of the Equitable in charge of this insurance plan and I recommend him to you as the proper one to whom you should go for advice on insurance and to make your purchases under this plan. He is located in Room 144, Extension 264.



It is with regret that we record the death of a friend and a valued member of our Technical Staff:

Harry Raymond Knettles

radio engineer

December 6, 1896—April 12, 1928

Associate of the American Institute of Electrical Engineers and of the Institute of Radio Engineers; for several years identified with the creation of the New York-London radio telephone circuit

News Notes

THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY has purchased the entire block front on Church Street, between Walker and Lispenard Streets, adjoining their present Walker-Lispenard building.

INCLUDED in the program of the Student Branch Convention of the New York Section of the A. I. E. E. was a trip through the Laboratories on the morning of April 19. The visitors included students from Columbia University, Newark College of Engineering, Cooper Union, College of the City of New York, Rutgers University, Stevens Institute of Technology, New York University, Brooklyn Polytechnic Institute.

THORPE HISCOCK, Communications Officer of the Boeing Air Transport Company, which operates between New York and Los Angeles, visited Whippany and the Laboratories on April 3.

AT THE COLLOQUIUM meeting on April 16 W. S. Gorton was elected President for the 1928-29 season, O. E. Buckley, Vice-President, and J. C. Steinberg, Secretary. M. J. Kelly spoke at the meeting on "Oxide Coated Filaments," and P. S. Olmstead, on April 2, spoke on "Adsorption of Gases by Carbon."

* * *

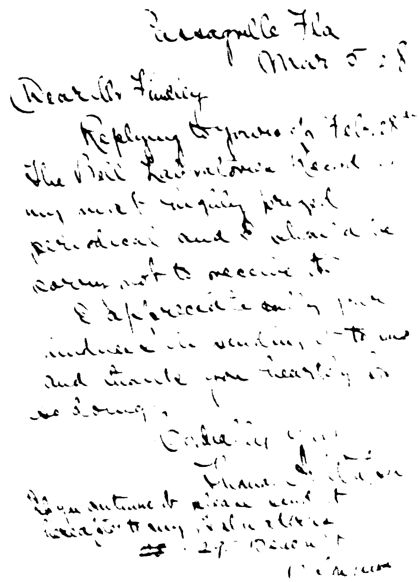
APPARATUS DEVELOPMENT

J. T. ACKER, H. A. ANDERSON, R. M. BURNS, C. H. GREENALL AND J. R. TOWNSEND attended the meeting of the A. S. T. M. Committee on Non-Ferrous Metals and Alloys, held in New York on March 21, 1928.

W. J. SHACKELTON was present at the meeting of the A. S. T. M. Committee on Magnetic Materials held March 22 in Washington.

W. J. LEVERIDGE visited the Victor plant at Camden, New Jersey, in connection with a new type nineteen-foot horn for music reproduction.

H. L. WALTER visited Philadelphia to assist in the production of reproducer outfits to be used in small theatres for non-synchronous music reproduction.


[illegible] Fla
Mar 5 [illegible]

Dear Mr [illegible]

Replying to yours of Feb [illegible]
The Bell Laboratories Record [illegible]
[illegible] periodical and [illegible]
[illegible] to receive it.
I appreciate [illegible]
[illegible]
and thank you [illegible]
[illegible]

Cordially yours
Thomas A. Watson

[illegible]

Reproduced above is the reply of Thomas A. Watson to a letter sent as well to many of those on the mailing list of BELL LABORATORIES RECORD, *enquiring as to their continued interest in the magazine*

R. V. TERRY visited Rochester to confer with the Bausch and Lomb Company, the Eastman Kodak Company, the Eastman Kodak Company and others on matters relating to equipment necessary for talking motion pictures.

W. V. WOLFE made an extensive trip which included visits to installations of carrier current telephone apparatus for the Northern States Power Company at Wissota and Eau Claire, Minnesota; the Portland Power Company at Portland and Salem, Oregon; and the Pacific Gas and Electric Company at Claremont, Vaca-Dixon and Pitt River, California.

H. PFANNENSTIEHL assisted at New Haven in installing and testing a new type universal projector base which has been developed for theatre use in connection with the reproduction of talking motion pictures.

G .W. FOLKNER AND A. C. GARRECHT visited the Nebraska Exchange in Philadelphia to study lubrication problems.

G. W. FOLKNER AND C. C. BARBER were in Hawthorne during the week of March 26 to confer on multiple brushes and sequence switches.

D. H. GLEASON AND D. W. MATHISON visited the Evergreen Exchange in Philadelphia to observe contact resistance studies on 200 type selectors.

D. T. MAY AND I. E. COLE attended a meeting of the Joint Sub-Committee on Development and Research of the National Electric Light Association and the Bell System held in New York on April 5.

H. O. SIEGMUND served recently on the Committee on Elections of the A. I. E. E.

H. A. ANDERSON visited the W. H. Buckingham Company at Binghamton, New York, on April 11 to discuss the manufacture of linemen's climbers.



At the Stockholm, Sweden, long distance board, a copy of the New York telephone directory lies within easy reach of the operator

H. M. STOLLER visited the Fort Wayne works of the General Electric Company during the first week in April to test a new type of direct current motor to be used for talking motion pictures. He was also in Philadelphia, testing and inspecting other new equipment for theatre installations.

E. C. MANDERFELD visited Philadelphia to test new control boxes for use with the motor equipment of talking motion picture apparatus.

AT PHILADELPHIA A. F. PRICE discussed the design and manufacture of apparatus required for talking motion pictures.

D. H. NEWMAN made a preliminary survey for the installation of a one-kilowatt broadcasting equipment for the Durham Life Insurance Company of Raleigh, North Carolina.

H. S. PRICE supervised the installation of a five-kilowatt broadcasting equipment for the Churchill Evangelistic Association of Buffalo, N. Y. He also inspected the one-kilowatt station of the Edison Electric Illuminating Company, Boston.

W. L. TIERNEY visited the Pacific Coast to make a survey for a five-kilowatt installation for the Los Angeles Express and to supervise the installation of a one-kilowatt broadcasting equipment for Don Lee, Incorporated, Los Angeles. While there he inspected the one-kilowatt stations of Hale Brothers and Don Lee, Incorporated, at San Francisco.

GENERAL STAFF

S. P. GRACE spoke on inverted speech and other recent developments of the Laboratories before the Kansas Independent Telephone Association at Topeka on April 4, the Ohio Independent Telephone Association at Columbus on April 12, and the Iowa Independent Telephone Association at Des Moines on April 18. On the following day, Mr. Grace addressed the Rotary Club and the Chamber of Commerce at Des Moines on the same topic.

P. B. FINDLEY gave a lecture "Through Electrical Eyes" before the Hazelton, Pennsylvania, section of the A. I. E. E. on April 20.

R. W. KING gave several lectures on television in Montreal, addressing the Canadian Railroad Club on April 10, the Electrical Club of Montreal on April 11, the Engineering Institute of Canada on April 12, and the employees of the Bell Telephone Company of Canada and the Northern Electric Company. On April 13 he spoke on the same subject before the Physics Society of McGill University at Toronto, and on April 23 he again lectured on television before the New Brunswick, New Jersey, Scientific Society at Rutgers University.

L. S. O'ROARK spoke on "Electrical Transmission of Personality" before the Lynn, Massachusetts, Section of the A. I. E. E. on April 25, and before the New England Chapter of the Telephone Pioneers on April 26.

RESEARCH

C. A. KOTTERMAN was in Washington, D. C., March 15 to 19, to supervise the installation of an automatic moving picture projector showing an exhibition picture "On Telephony." This apparatus is part of the permanent exhibit of the Bell System at the National Academy of Sciences.

H. H. LOWRY, J. M. FINCH AND H. N. VAN DEUSEN visited the research department of the Bakelite Corporation in Bloomfield, New Jersey on April 4.

A. R. KEMP AND W. S. BISHOP visited the E. I. Du Pont de Nemours Company at Wilmington on April 5, to discuss vulcanization accelerators and antioxidants for rubber.

H. E. IVES lectured on the transmission of pictures before a meeting of the Illuminating Engineers' Society held in the A. T. & T. Auditorium at 195 Broadway on April 12.

COOPERATING with the New York League for the Hard-of-Hearing, Harvey Fletcher and J. B. Kelly arranged for a showing of certain motion pictures illustrating the use of audiometers at the Parents Exposition, held at Grand Central Palace, which began April twenty-first. Mr. Kelly also gave a demonstration of

the 4-A Audiometer in connection with the portion of the program allotted to the New York League for the Hard-of-Hearing. The League's booth at the exposition displayed a placard that was made up by John G. Marinac, a member of the Bureau of Publication.

J. B. KELLY spoke on Recent Researches in Audition before the Ohio Academy of Sciences at Cincinnati.

SYSTEMS DEVELOPMENT

R. C. DAVIS AND C. H. ACHENBACH spent the week of March 5 at Hawthorne discussing the introduction of the new cordless "B" switchboard for panel dial systems, arranged for distributing calls between the operators.

F. A. KORN visited Columbus to confer with engineers of the Ohio Bell Telephone Company on new dial equipment.

F. A. COX investigated requirements for panel dial equipment in Philadelphia.

J. L. DOW visited Pittsburgh March 27 and 28 to discuss panel equipment with engineers of the Bell Telephone Company.

E. W. HANCOCK inspected the new No. 701 P. B. X. in the Western Electric Distributing House at Chicago.

C. W. GREEN spent several days at the Universities of Wisconsin and of Illinois interviewing students in regard to employment.

F. H. CHASE AND R. E. CRANE spent several weeks at Hawthorne observing performance tests on type "C" and type "D" carrier systems.

G. W. AMES visited Denver to test filter equipment for carrier systems.

A. C. DICKIESON studied field conditions on the type "D" carrier system at Atlanta, Macon and Canton.

W. J. BOHRMAN attended the cutover of a new satellite dial system exchange at Whitesboro, New York.

C. H. BIDWELL attended field trials of a new method of producing tones at Springfield, Massachusetts, and Hartford, Connecticut.

M. A. FROBERG tested commercial generator equipment at Indianapolis.

E. H. SMITH discussed step-by-step problems with engineers of the Automatic Electric Company at Chicago.

INSPECTION ENGINEERING

W. A. BOYD AND O. S. MARKUSON attended regular Survey Conferences at Hawthorne during the latter part of March. R. M. Moody and H. C. Cunningham attended a similar conference at Kearny.

W. C. MILLER AND R. V. TERRY visited the Bausch and Lomb Optical Company in Rochester on March 25 and 26 to discuss the manufacture of a lens system to be used for sound reproduction with motion pictures.

E. F. HELBING was in Schenectady on April 11 and in Utica on April 12 to observe the operation of Foos Type T Emergency gas engines.

OUTSIDE PLANT DEVELOPMENT

C. D. HOCKER was in St. Louis and Chicago during April studying leather tanning and the manufacture of leather products.

J. A. CARR visited Wakefield, Rhode Island on April 3 for studies in regard to placing of cable rings.



"Shadows," by E. Alenius; first prize, Landscape Class



"Shoes," by E. Alenius; first prize, Still Life Class

Club Notes

The second annual photograph contest included pictures from Finland, Italy, England and Bermuda, but a scene from our own Greenwich Avenue took first prize in the Landscape Class. This was "Shadows" by E. Alenius. M. K. Kruger's "Brook" took second place, and "Birch Tree" by A. C. Chaiclin was awarded third place in this class.

The first prize for portraits went to P. Husta for his picture "The Baby," while C. G. Schofield's "The Slave Girl" took second place, and J. Popino's "Theresa," third. Other portraits received favorable comment.

The first and second places in the Still Life Class were taken by E. Alenius' "Shoes" and "The Jewel Case." C. G. Schofield won third prize with "Table Top." A. O. Casey received Honorable Mention.

A. C. Chaiclin was awarded Honorable Mention for his group of pictures.

Representatives of seven departments competed for the Department prizes. The awards were given to A. O. Casey, Apparatus Development; J. E. Clark, Research; E. Alenius, Systems Development; D. D. Haggerty, Personnel; J. Popino, Commercial; J. A. St. Clair, Inspection Engineering, and D. E. Hartshorn, Patent Department.

The exhibition was judged by Dr. W. H. Zerbe, who is connected with the staff of the New York Herald-Tribune and with the Brooklyn Institute of Arts and Sciences.

There is a possibility that the Club may arrange some interesting talks on photography, if there are enough members interested. For further information, call K. B. Lambert on 1366, or Margaret Horne on 786.

Handball

The second annual handball tournament of the Club was held on Tuesday and Thursday evening during March at Labor Temple, with twenty-four men taking part in the elimination matches. T. J. O'Neil, repeating his victory of last year by defeating A. E. Hague in the final match, received a wrist-watch as first prize. A. E. Hague won the second prize of a five-dollar order, and A. L. Dresch was awarded a two-and-one-half dollar order. A Club team was selected to play in a Bell System Handball Tournament which started Tuesday evening, April 3, in the gymnasium in the Hudson Street building of Western Electric.

Track and Field

On Saturday afternoon, June 16, the Bell System Athletic League will hold the first intercompany track and field meet at Erasmus Hall High School Field. The program will include thirteen events which are listed as follows: For men—100 yd. dash, 220 yd. dash, 440 yd. dash, 880 yd. run, shot put, high jump, broad jump, mile relay, novelty race and tug of war. For women—60 yd. dash, quarter-mile relay, and basketball throw.

Fourteen branches of the Bell System in the metropolitan district will



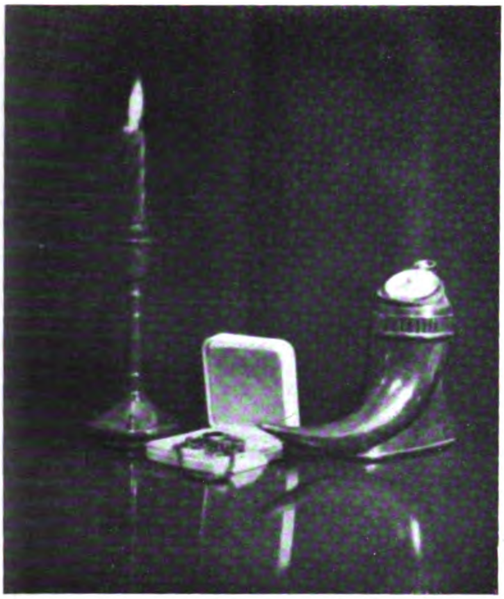
"The Baby," by P. Husta; first prize, Portraits



"Theresa," by J. Popino; third prize, Portraits



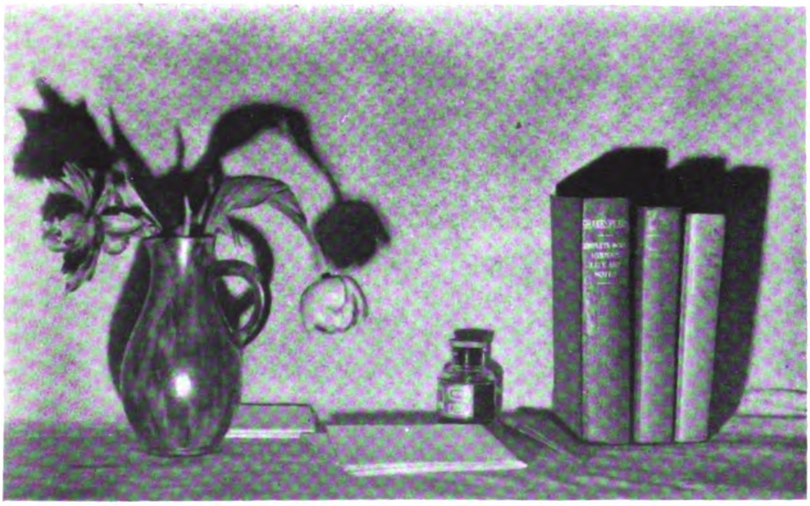
"The Slave Girl," by C. G. Schofield; second prize, Portraits



"The Jewel Case," by E. Alenius; second prize, Still Life Class



"Birch Tree," by A. C. Chaiclin; third prize, Landscape Class



"Table Top," by C. G. Schofield; third prize, Still Life Class

compete in this meet, and each will be limited to three entries in each event except the tug of war and relay races, in which each organization will enter one team. The athletic committee of the Bell Laboratories Club will hold tryouts for the track team at Erasmus Field on May 19 at 2:00 P. M. Communicate at once with either L. P. Bartheld, extension 749, or D. D. Haggerty, extension 542, if you intend to participate in these tryouts, at which, incidentally, prizes will be awarded. Strong men should call W. C. Calmar, manager of the tug of war team.

The prizes for the meet on June 16 include eight Elgin watches for first places, silver medals for second and bronze medals for third, for many of the events.

Golf

The third and last men's indoor golf tournament of the season was held on Tuesday evening, March 27, at the Vander-Built-In Golf Course. In point of numbers this last tournament was the best, eighty-three players who took part bearing witness to the growing interest in golf which is evident among members of the Laboratories.



"Brook," by M. K. Kruger; second prize, Landscape Class

In the qualifying rounds, consisting of thirty-six holes of medal play, L. G. Hoyt and H. Wood led their respective groups. E. C. Mueller had to down such formidable opponents as J. Dusheck, L. G. Hoyt and R. C. Koernig to win the Group 1, Class A prize, and H. Wood, winner of the Group 2, Class A trophy also had to overcome keen competition. The consistently fine putting of J. G. Roberts gave him a victory over A. A. Reading in Group 1, Class B, and W. C. Burger won from H. L. Dowing in Group 2 of the same class. In the Class C, Group 1 competition O. H. Danielson defeated W. F.



At the Montreal end of the Montreal-New York chess match

Johnson and in Group 2, H. Leicht defeated G. W. Burr. In Class D, Group 1, G. F. Doppel defeated H. W. Dippel, while in Group 2, A. I. Crawford won from P. R. Brousse.

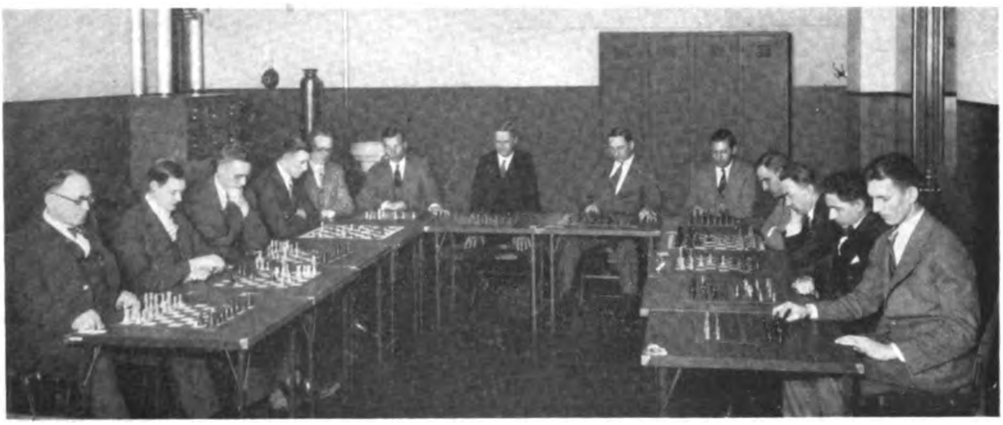
A new feature was introduced in this tournament in the form of two novice prizes for players who, having played in more than one of our tournaments, had never won a prize. N. H. Thorn won one of these, and E. K. Eberhart the other.

The success of the indoor tournaments during the past season has been due in no small measure to the coöperation of Mr. Mothersele, proprietor of the Vander-Built-In Golf Course. In each of our tournaments he has voluntarily contributed valuable prizes. His last contribution, consisting of a pair of splendid wooden clubs, was won by H. Wood.

The next tournament will be held outdoors. The qualifying round will be played on the links of the Salisbury Golf Club on Saturday, June 2, and the finals on June 9.

Baseball

The Bell System Baseball League of New York opened the 1928 season on April 30 at 6:00 P. M., at



The Laboratories group that played Montreal

Erasmus Hall Athletic Field and the Laboratories team will play its first league game on Tuesday evening, May 1. The League this year is composed of fourteen teams instead of eight, and has been divided into two groups of seven teams each to provide enough playing days. Complete printed schedules of all league games may be obtained in Room 164. The Laboratories schedule is as follows:

May 1 Western Electric, 195 Broadway.
May 11 Western Electric, Hudson Street.
May 25 New York Telephone, L. I. Plant.
June 6 New York Telephone, L. I. Traffic.
June 19 Western Electric, Installation.
June 29 New York Telephone, Long Island Commercial and Engineering.

The winning team in each group will receive one of the Spalding trophies, and will then be required to play a series of post-season games for the League championship. Fifteen prizes valued at one hundred and fifty dollars will be given to the players on the team winning the series.

The officers of the Bell System League for 1928 are as follows:

President, D. D. Haggerty, Bell Leboratories.
Vice-President, R. S. Kirkwood, N. Y. Tel. Manhattan.
Secretary-Treasurer, E. H. Straus, N. Y. Tel. Long Island.

The Club Interdepartmental League will open the 1928 season on Saturday, May 5, at Erasmus Field and with the exception of May 12 and June 16, games will be played every Saturday through July 28. This season the baseball committee has arranged the schedule so that all games will be completed before August 1 to avoid conflict with the August vacation schedules.

Chess

For the fifth consecutive year the Laboratories team has won the championship in the Commercial Chess League of New York, and in that time has not lost a match. This year ten teams representing commercial houses and banks competed for the league trophy. The final standing in the league is as follows:

	Won	*Lost*	*Drawn*
Bell Telephone Laboratories	8	0	2
Chase National Bank	8	1	0
Western Union Telegraph Co.	6	2	1
Brooklyn Edison Co.	6	3	0
Guaranty Trust Co.	4	3	2
New York Edison Co.	2	5	2
Western Electric Co.	2	5	2
J. C. Penney Co.	1	5	3
McGraw-Hill Co.	1	7	1
H. L. Doherty Co.	0	6	3

Hawthorne defeated West Street by a score of six to four in the annual telegraphic chess match which was played on Saturday, March 31.

The Laboratories team won by 7½ to 4½ the telegraphic chess match played April 14 with the Telephone Chess Club of Montreal, the first such match with Canada to be conducted by means of printing telegraph apparatus. Play started at 2:30 and continued until 11:30 with an hour's intermission for dinner. The referee was Mr. H. Helms, Editor of "The American Chess Bulletin"; Dr. E. A. Robertson, President of the Montreal Chess League and of the Montreal Chess Club, represented our players in Montreal; and Mr. D. G. Grimley, formerly a member of our team, held up the interests of the Canadians here. J. H. Feeny was captain of the Montreal players, and H. D. Cahill our captain. The final standings:

	Montreal	*Board*		*New York*
½	G. Gaudet	1	½	F. A. Voos
½	W. H. Rawlings	2	½	R. L. Dempsey
½	W. K. Detlor	3	½	H. W. Bode
½	J. L. Clarke	4	½	H. D. Cahill
0	A. L. Buckland	5	1	D. A. Quarles
0	W. G. Brisbane	6	1	H. T. Reeve
1	W. M. Paterson	7	0	E. G. Andrews
0	R. H. Spriggs	8	1	A. Grendon
0	J. H. Feeny	9	1	G. H. Heydt
½	G. R. McGregor	10	½	T. Slonczewski
½	J. Carleton	11	½	W. Kuhn
½	G. Goumy	12	½	E. Breny
4½			7½	

BELL LABORATORIES RECORD

SYSTEMATIZED RESEARCH
By H. D. Arnold

VAIL MEDAL AWARDS

EMERGENCY POWER PLANTS
By V. T. Callahan

JUNE 1928 VOL. 6 No. 4

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Systematized Research

By H. D. ARNOLD
Director of Research

ONE of the most characteristic features of research is its demand for individual initiative and resource; and its most valuable results often come from plans of procedure and methods of experiment originated during the actual progress of work.

To attempt to order in advance the detailed conduct of a problem would be undesirable and futile and would indeed violate the very spirit of research, which is one of self-reliant adventure along uncharted paths. Any proposal to limit too closely the initiative of the experimenter is bad; and its adoption would be certain to impose upon results the fallacies inherent in prejudgment. Nevertheless, a broad and careful consideration must be given to each research at its inception, for the course of experimentation is long and costly and not to be lightly attempted.

It is to the consideration preliminary to undertaking a research that I wish to direct attention under the general caption of "systematized research." The words imply a plan and method actively impressed upon the research from without. The advantages of such an external control and the limitations within which it must operate have been subjects of growing interest during the past few years; and I have no doubt that those of you who continue actively in research during the next decade will find them demanding increasing consideration. Scientists are trained in the constant effort to display the reign of order in the realms of nature; and this schooling predisposes them to a lively interest in attempts to impose orderliness upon their own diversified efforts. In the last few years, moreover, an added incentive has arisen through the growth and success of systematized research in industry.

It is interesting to recall the situation that developed fifteen or twenty years ago, when research in industrial laboratories first came into prominence as a matter of broad concern. Its place was not then clearly

This paper is a transcription of a talk at the annual dinner of Sigma Xi, at Columbia University, April, 1928.

apparent and its growth was the cause of some distrust among those who worked within university precincts and were financed from university funds. An attempt to set a gulf between the two fields was a natural enough gesture for the protection of research in universities against possible encroachments of research in industries. Industries differ from universities in their objectives, their organizations, and their methods of finance; it is quite understandable that they should differ also in their attitude toward the conduct of research. It was conceivable that industries might promote in their work a spirit and a method which, if commonly accepted, would react disastrously upon the fundamental progress of science. The passage of time has shown, however, that the two fields are not antagonistic, nor even competitive, but are complementary.

A little reflection shows that there is not much difference in the underlying motives of workers in the two fields. Their training is identical; and once they have set foot upon a promising trail both are enthralled in the interest of the chase, and neither needs bow to the other in the integrity and thoroughness of his pursuit.

It is in the method of choosing problems, rather than in the mental or mechanical attack upon them, in which there is, and should be, the greatest difference. In an industry, fortunately, the systematizing of research is comparatively simple. The evolution of any industry will have marked off its general field of interests; its operations will have accumulated evidence of needs or deficiencies which can be weighed and interpreted by minds accustomed to research methods; its facilities will provide immediate avenues of attack; and its commercial requirements will serve in evaluating results which it may seem possible to achieve. Its research must follow a plan, however flexible, in which there is a conscious and never-flagging effort to secure for the industry the maximum ultimate financial return from the money expended. The plan will be determined by such considerations as the timeliness and relative urgency of the various problems, the probability of success, the value of the possible results, and the adequacy of available funds, man power, and technique. Within this plan the individual scientist accepts a problem and conducts his work, knowing that his value will be appraised upon his performance. Because he has accepted direction in his choice, and in the measure that his work is part of a systematized attack, he is relieved of some of the hazard of ill success should his problem prove insolvable, or should its solution find no application.

Not quite so simple is the situation determining the choice of problems in a university, for there we find two concurrent objectives. The research funds of the institution are intended both to promote additions to knowledge, and to provide for the training of new minds in research. The success of a department is measured by the number and quality of the men who complete their training as well as by the apparent importance of the department's publications. Students must choose, or have suggested to them, problems which can be completed in a rather short specified time, problems which are of sufficient importance to stand by themselves as contributions to knowledge, which

are so timely as to attract some attention, and which, nevertheless, will not run so closely along the line of work of another as to involve too great a possibility of being forestalled in publication. The scientific repute of the department as a whole rests, however, upon persistent and monumental contributions in a particular subject. Heads of departments find themselves too frequently perplexed in the conflicting efforts toward sufficient diversification to meet the needs of their students and toward sufficient concentration to permit consistent and cumulative work in the field where they see most promise of success from their personal efforts.

In the universities the need to systematize research becomes more apparent and pressing as the field broadens and the number of workers multiplies. The student is rightly and wisely encouraged to seek a problem for himself. He finds himself, however, partly by choice and partly by chance, in a laboratory best equipped for a certain line of work, and associated with a teacher whose interests incline for the moment toward a special subject. He makes a choice under these circumstances as best he may. If he follows the line of his professor he may find himself making an essentially minor contribution, but one which nevertheless acquires some degree of prominence because it is a part of a systematized whole. In this respect he accepts certain conditions and avoids certain hazards as does his fellow worker in systematized industrial research. If he chooses a course outside the established line he may reap a spectacular reward, but all too frequently his work goes promptly to the limbo of dusty shelves, because although thoroughly good it is untimely or, inadequate in itself, it rests without fruition or extension. The professor, for his part, finds himself torn between the urge to use his students in forwarding lines of work with which he is thoroughly familiar and which he believes are valuable, and the fear lest by so doing he may unduly narrow the student's attention and thus hinder his view of other parts of the field which may become the scenes of greatest activity in the immediate future. Under these circumstances it is natural that questions rise as to how university research may profit by a more directly systematized effort, and as to the pitfalls which are to be feared if such a course is pursued.

The call to systematize research has found its most immediate answer, outside the industries, in the establishment of national and international bodies for the consideration of problems, the rendering of financial aid and the interchange of information. These organizations must find their way carefully and have already proved of great value, especially in furnishing material and financial aid to a large number of research men who already had definite problems in mind. In choosing among these men and problems the ones to assist, it is obvious that they exercise a conscious direction of the trend of advanced research. Meantime, the vast opportunities of science now open present many more points of attack than there are workers. Since this is so it seems most unfortunate to find, as we sometimes do, students in two institutions vying as to which shall be first to complete the same problem. And it seems almost as unfortunate that the weight of student effort should at times be massed in one part of a field

while another of comparable importance is left relatively uncultivated. An obvious method of coping with this would be to systematize student research through some central organization. But while a degree of centralized control might be acceptable it would necessarily intrude upon the autonomy of separate institutions and if carried too far would give rise to violent reactions. This indeed presents a most efficient safeguard against too great centralization, and we need never fear that we shall drift unwarned into a condition in which personal initiative is too much restrained.

Attending any effort to systematize research there are definite dangers, but these are all, I believe, of a transient nature and tend to generate their own safeguards within a reasonable time. Chief among them, in the industrial field, is the chance of killing the research spirit of the individual worker by limiting his initiative through an unwise effort to hold to procedures determined in advance of, and therefore in ignorance of, the facts. This becomes of real magnitude when the control of research is exercised by those too far removed from or too little acquainted with its actual performance. It is easy and sometimes seems far more economical of time and money to plan a detailed method of attack, through a central organization, as well as to choose the subject of a research, but a broader view quickly shows such a policy to be short-sighted when for the sake of immediate economy it puts in jeopardy the future creative power of the individual.

In systematizing industrial research another danger lies in the temptation to limit the choice of problems too closely to the immediate needs of the industry and to be a little intolerant of a desire to follow leads into new fields. It is not particularly difficult to secure support for researches that have a high probability of immediate profit, but it is quite a different matter when the proposal is to sacrifice immediate returns in order to concentrate on more forward-looking investigations of less certain outcome. The principal loss which comes from restricting problems too narrowly to matters of current interest is, of course, the ultimate financial one to the industry, but carried too far such a policy may seriously react upon the research worker himself for it tends to dull his vision of possible new avenues of research which may appear during the progress of his work and which, if passed unregarded, may not come to the light again for years.

Corresponding dangers are present in any attempt to systematize research in the universities. The pressing need for immediate results may be very apparent to those who are advising on the general plan; and with their greater experience they may find it hard to refrain from too particularized directions when the man on the job seems to be slow and uncertain in his attack. The obvious risks of yielding to this impulse are that the student will tend to become a highly trained laboratory assistant rather than an independently minded investigator and that the work will proceed too much according to past traditions with an accompanying lack of new discoveries in methods of experimentation.

Furthermore, there is very real danger in attempting even to suggest subjects for university research in accordance with a comprehensive plan.

Combined experience may justify an opinion as to the portions of the front where the attack is lagging, but who can tell where an avenue of progress is about to open or the value of that which lies just ahead? Nevertheless a greater degree of orderliness in the choice of subjects seems desirable and little to be feared, for, fortunately, the very conduct of research fosters the growth of mental independence and although for a time science might suffer from an attempt to hold subjects within too narrow bounds, no limits of such a nature would long be respected.

I have not attempted to argue the case for or against any particular plan or scope of systematized research. This is a matter where little is to be gained by haste toward organization, and the situations differ among the various sciences. I have simply tried to turn your thoughts for a few moments from the compelling and clear-cut interests of your individual problems to the broader but more hazy picture of research management. The greatest fascination of research lies in the uncertainty as to what is just ahead, and no one knows better than the research worker the futility of too careful thought for the future. To be mentally self-reliant, to be persistent and alert and to keep one's judgment unbiased by preconceived notions are among the essentials for success in the conduct of any research problem. How far these may be consistent with more consciously systematized plans of attack along the front of each individual science is the future "management problem" of both industrial and academic research.

Site Purchased for New Radio Station

To provide a site for an additional receiving station for transatlantic radio-telephony, the American Telephone and Telegraph Company has assembled by purchase and lease a tract of 450 acres near Flanders, New Jersey. By association with a transmitting station at Deal Beach, and appropriate installations overseas, a new short-wave channel to Europe will be established. These additional facilities are required to care for the rapidly increasing load, which has already reached nearly sixty calls a day.

New Standards in Emergency Power-Supply Units

By V. T. CALLAHAN
Systems Development Department

POWER for telephone central offices is normally obtained from the local electric power lines. The supply is, in general, reliable; rarely is the current off or the voltage or frequency unsatisfactory for more than a few moments at a time. When such interruptions occur, power is drawn from a local battery which is of ample size to supply all needs for several hours. Telephone service, however, above everything must be available at all times and regardless of all emergencies. On rare occasions, floods or other catastrophies entirely beyond the control of the electric utilities may cut off the power supply for an extended period. To insure the continuance of telephone operation in such cases, it is the usual practice to provide an emergency power supply which is independent of outside power lines in cases where only a single source of power is available.

To furnish this emergency supply, generators driven by internal-combustion engines are used. A large range of capacities from one and one-half kilowatt direct-current farm lighting units to sets of one hundred kilowatt alternating-current rating are required and have been available in a relatively large number of sizes and types of sets. The increase in reliability of the commercial power supplies, the adoption of gasoline as fuel for emergency engines, and the tendency toward the use of two or more small emergency sets rather than one large set have resulted in an effort to decrease the number of standards and to effect the economies resulting from an increased demand for fewer types. The various types and requirements have therefore been reviewed; and, in collaboration with the Buffalo Gasolene Motor Company, the Laboratories have now developed a group of emergency power-supply units consisting of three sizes of Buffalo engines with three sizes of Western Electric and two sizes of Star Electric low-voltage direct-current generators and two sizes of Western Electric alternators which will cover the range from twelve to fifty kilowatts. Requirements below twelve kilowatts are filled by the Westinghouse 1.5 kw sets singly or in multiple, and requirements above 50 kw will be taken care of by the use of a larger type of Buffalo engine now being developed. The three sizes of the two new types of engines with various generators used singly or in multiple will replace eight sizes of two types of engines now standard and four older types used occasionally, as well as three types of engines used extensively on a trial basis.

For the lower part of the range covered by the newly-developed line, the twelve-kilowatt four-cylinder Buffalo Type BA gasolene engine has been adopted, direct-connected to and

mounted on a common sub-base with a Star Electric generator. To reduce the cost to a minimum, all but absolutely essential accessories have been eliminated. No engine governor or generator field rheostat is used, the output of the generator being regulated entirely by means of the engine hand throttle.

The subbase of the new set is equipped with four coil springs for support. These springs with the flexible sections in the piping system prevent the transmission of the engine vibration to the building and so permit the set to be mounted directly on a floor of ordinary construction. This spring mounting, not evident in the photographs, is a simple and effective arrangement which may be understood by reference to Figure 1. The set, which comes as a unit, is placed in position and the plugs over the springs are then screwed down till the under surface of the subbase

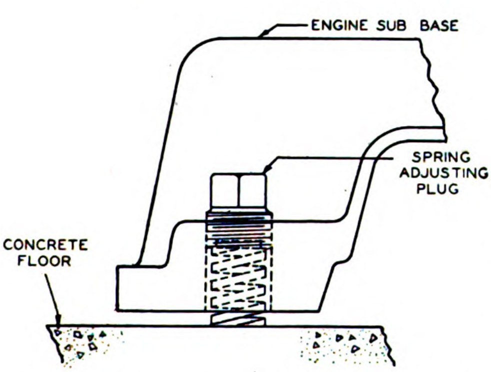
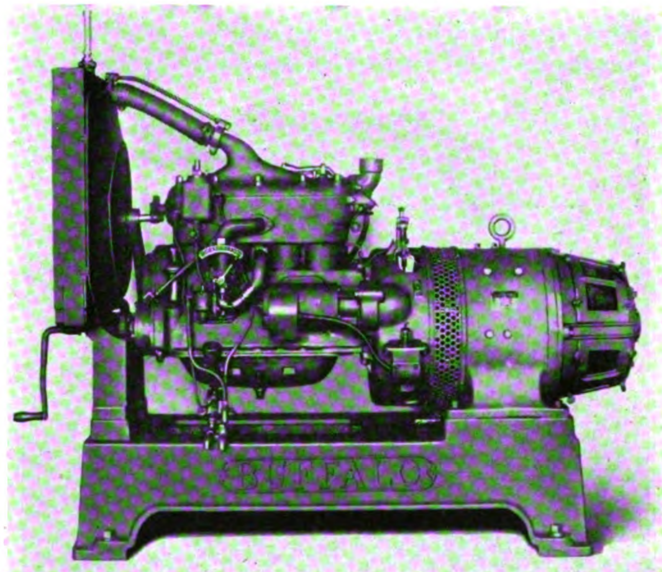


Fig. 1—Detail of spring-mounting for engine bases

just clears the floor. The entire load is then carried on the springs. This eliminates the expensive concrete foundation which is to be seen in such a large number of installations of this nature in the industrial field.



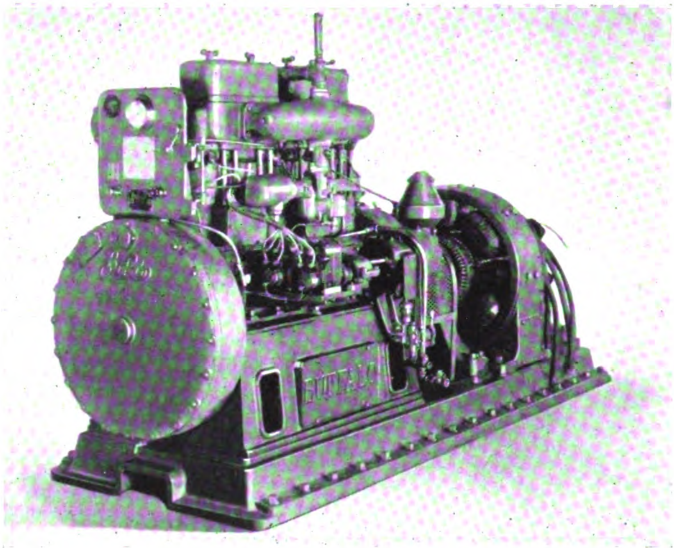
Buffalo Type BA Engine Generator Set showing radiator for cooling the circulating water

A high-tension magneto is furnished for ignition and an overspeed trip for grounding the ignition to stop the engine in case of excessive speed. The engine is arranged for both electric and hand starting. Cooling is normally by means of city water but where there is only a local water supply, inadequate sewers, or where other reasons make it desirable, a radiator may be used, as shown in the photograph. A fuel pump mounted on and driven by the engine pumps gasoline from a tank buried beneath the basement floor or located in some other safe and convenient place, to a small auxiliary fuel cup fastened to the engine frame. Lubrication of the internal working parts is accom-

plished by a splash feed system while main bearings and gears are fed by means of a low-pressure oil pump and piping. The generator control equipment is mounted on a panel located beside the generator.

Two capacities of commercial-type low-voltage direct-current generators are direct-connected to this type BA engine. One has an output of two hundred amperes within the range from twenty-two to sixty volts which permits floating of batteries having from eleven to twenty-five cells. The other has an output of four hundred amperes from twenty-two to twenty-eight volts for floating eleven- and twelve-cell batteries. The new sets of this type cost approximately one-half as much as the former types of the same rating which they replace.

For the upper part of the range covered by the newly-developed line the recently-designed type "R" engine was adopted. A four-cylinder engine is used for the smaller sizes of low-voltage direct current generators or the small alternator and a six-cylinder for the larger generator or the large alternator. This engine is of the valve-in-head type and has a governor to maintain closer speed regulation. Direct current generator voltage control is accomplished by means of a field rheostat. The generator or alternator control equipment is mounted on a separate power board.



Buffalo Type R Engine driven set which also uses the spring mounted base

These engines are arranged with duplicate high tension magnetos for ignition, forced feed lubrication, and for cooling by city water. The overspeed trip, starting motor, and fuel pump are in general of the same construction as employed with the type BA engine. A spring-type mounting is used also so that the set may be mounted directly on a floor of ordinary construction. The springs and the flexible connections in all piping prevent the transmission of engine vibration to the building.

The four-cylinder type R engine will be arranged to drive a five-hundred-ampere, 53-volt, or a one-thousand-ampere, 28-volt, direct-current generator or a 50-kilovolt-ampere alternator. The thousand-ampere generator is used for floating eleven- or twelve-cell batteries and the five-hundred-ampere generator will float twenty-four-cell batteries.

The six-cylinder engine is arranged to drive either an eight-hundred-ampere, 53-volt direct-current generator

or a 75-kilovolt-ampere alternator.

In addition to the reduction in the number of different sets used, material savings in floor space will accrue, as it has been found possible to eliminate all the older belt-driven sets employing single-cylinder horizontal engines. Economies are also expected due to freedom from special building requirements, easier installation, and improved maintenance and operating results. Using these unit engine sizes makes it economical to furnish units nearer the requirements of the initial power plant, supplying an additional set or sets as the power plant grows. With these sets, the use of compact units, which has proved so successful and beneficial in a great many other parts of the telephone plant, will be extended to our emergency power-supply problems.

New Standard Units

Engine Type	*Generator Ratings*
BA—4-cylinder	200 amp., 22-60 volt d.-c. generator
	400 amp., 22-28 volt d.-c. generator
R—4-cylinder	500 amp., 44-53 volt d.-c. generator
	1000 amp., 22-28 volt d.-c. generator
	50 kva alternator
R—6-cylinder	800 amp., 44-53 volt d.-c. generator
	75 kva alternator

Offer of Additional Shares of A. T. & T. Stock

Stockholders of the American Telephone and Telegraph Company of record June 1, 1928, *are privileged to subscribe at par for one additional share for every six held. Subscriptions are payable as follows:* $20.00 *per share on August* 1, 1928, $40.00 *on December* 1, 1928, *and* $40.00 *on April* 1, 1929. *Interest at five per cent will be allowed, making the final payment* $38.65. *Those who wish may pay in full on August* 1, *or complete their payments on December* 1.

Warrants evidencing subscription rights will be mailed to stockholders on June 11. *Fractional warrants, entitling the holder to subscribe for less than a share of stock, must be combined. Purchase and sale of warrants may be handled through the Financial Department of the Laboratories.*

Sound-proof Rooms

By J. G. MOTLEY
Assistant Plant Manager

FOR research on sound reproduction and for development of transmitters and sound-reproducing apparatus, it is important to have working space as nearly soundproof as is practicable. Rooms deadened with hair felt and other absorbing materials have been provided for a number of years, but newer methods of sound measurement and improved transmitting and receiving apparatus have made it necessary that sound be excluded more completely than is possible in rooms of that type. Meanwhile theories of sound absorption developed in recent years by the Research Department have brought to light important considerations governing the design of sound-proof rooms. Fortunately there became available a new building material, boards of matted vegetable fibre commonly used for heat insulation and known by trademark names such as Celotex, which provided a ready means of meeting the new requirements.

Despite the general impression that sound absorbers are the main factors in rendering a room soundproof, our rooms are started with brick walls four inches thick, laid with cement mortar and covered on both sides with hard cement plaster. This base, as solid and massive as the building structure permits, provides a system having a low fundamental period, with a minimum tendency to resonate and a maximum tendency to reflect sound. On the same basis, the doors are built of two thicknesses of ¼" steel plate, separated by an air space and braced to prevent drumming action; they are fastened by clamps similar to those used on watertight bulkhead doors.

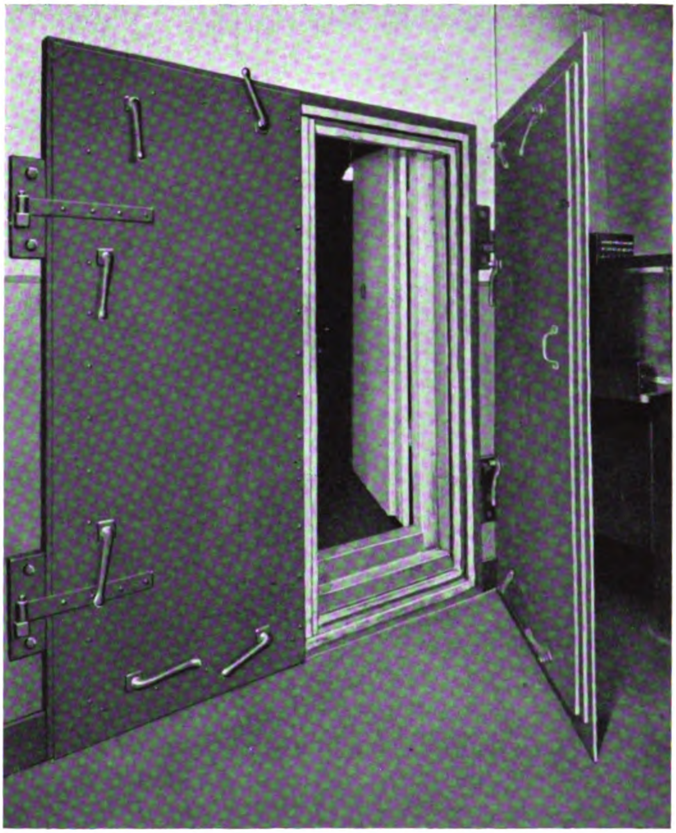
Inside the masonry wall, and separated from it by a continuous air space to reduce the transmission of building vibrations, is an inner room consisting of laminated walls built on a light framework of wood. Outermost in walls and ceiling is a layer of Celotex to damp any sounds conducted by the masonry; next is a sheet of metal 1/16" thick, which reflects sounds back into the absorbing fibre; within are four successive layers of Celotex. The last of these serves the dual purpose of absorbing incoming sound and of preventing the reflection of sound produced inside the room. The floor of the inner room is of two-inch boards, with a layer of 1/16" sheet metal above and with Celotex both above and below; the wearing surface is a quarter-inch layer of linoleum. Supporting the floor, and thereby the walls and ceilings, are blocks of wood resting on a layer of Celotex with which the concrete floor of the building is covered.

The layer of metal was adopted primarily to increase the mass of the inner room and to provide a hard, sound-reflecting surface. It is continuous on walls, floor and ceilings, and at the jambs of the door it overlaps with the metal on the door itself.

In certain of the rooms the metal sheets are of copper to provide an electrical shield, but in the majority galvanized iron is used, since it is quite as effective as a sound reflector, is much less expensive, and has a certain amount of shielding value in addition.

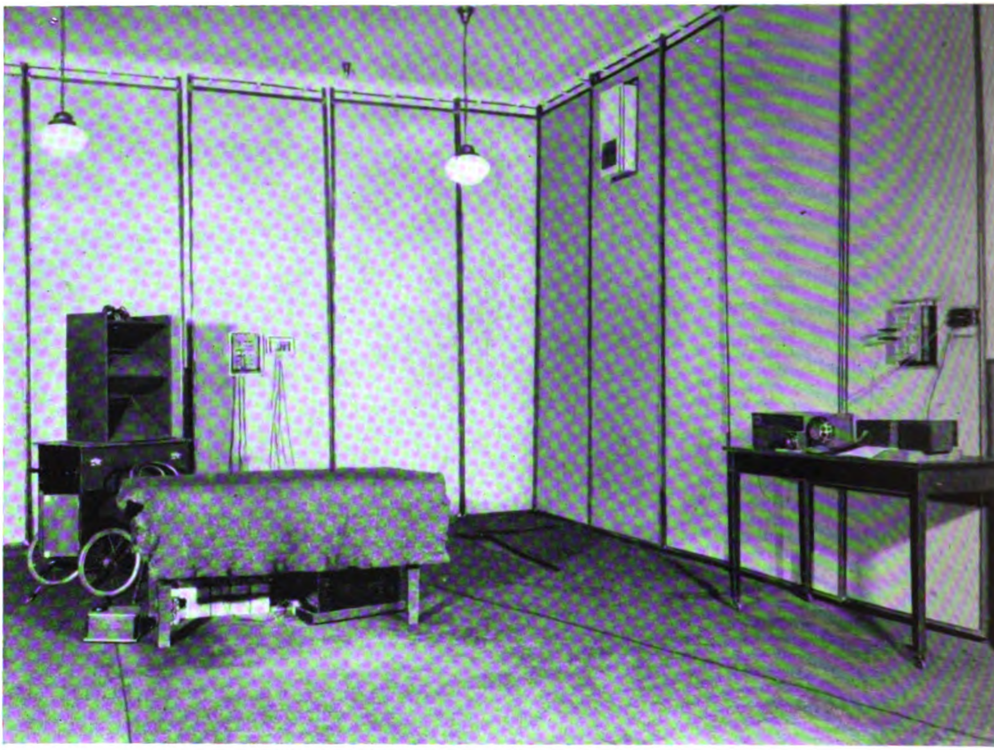
That its full soundproofing value may be obtained, each inner room is supported on as few wooden blocks as possible. As a further means of reducing physical connection of the inner room to the masonry of the building structure, studding of the inner wall frame rests on the Celotex covering the wood fibre of the inner room. Care has been taken likewise to restrict to a minimum the solid material passing through the inner layers of Celotex. On that account flexible electric connections are used, and the last three layers of the fibre are fastened into place with glue rather than with nails. During construction it became apparent that the smallest opening permitted entrance of sound. Outer and inner doors are arranged therefore to be clamped against cushions of rubber foam.

The precautions for preventing leakage of sound make the room airproof as well. For the necessary ventilation, a labyrinth-like duct runs to and from each of the rooms. The outer walls of the duct are of cement plaster, applied directly to a base of Celotex. They are lined with Acoustic Celotex, and then with a layer of hair felt. The air passages are wide and the velocity slow, so that sounds are quite effectively absorbed by the time the air has gotten to the room.



Doorway of the largest sound-proof room, showing strips of rubber foam to assure tight fitting

Thirteen rooms have been built according to the construction described, ranging in floor area from approximately 900 square feet to 50 square feet. They are sound-proof and sound-absorbent on the inside so far as the higher frequencies are concerned, but the lower frequencies do transmit through the entire structure. It is interesting to note that, as the room becomes more nearly sound-



Room 1072, *whose acoustic properties are varied by means of Celotex panels along the walls and by strips of hair felt*

proof, listeners become more sensitive to small volumes of sound from the outside. A theoretically sound-proof room seems therefore to be impracticable with our present knowledge.

A large room of somewhat different construction, 600 square feet in floor area, has been provided as well, for aid in the study of the effect of room acoustics on the action of transmitters and receivers. It is built with the same solid masonry walls as the other rooms, finished with hard plaster, and with the same metal doors. Within are hangers along the walls at the top, from which there are suspended removable panels of sound-absorbing material so that in any location the thickness of the absorbing material can be varied, and the acoustic properties of the room changed correspondingly.

The Light of a Television Eye

By FRANK GRAY
Research Department

"IN the act of seeing, light comes out of a person's eyes and explores the object at which he is looking." So believed certain Greek philosophers, who considered light as an intangible tentacle, proceeding from and directed by the eyes of an observer. What a comfort it might be to proponents of this long-discarded theory if they could know that our television system apparently sees by shooting a beam of light from what looks like its eye! Appearances deceive; the lens at the center of the television transmitter merely functions with other apparatus to direct a beam of light, and the seeing is done by three photoelectric cells which are grouped around the face of the instrument.

Still the difficulty persists. Long familiarity with cameras leads one to expect that the television transmitter will look through a lens at a broadly-lighted object, and then in some way convert the image of that object into electrical signals which can pass over a line. Most television schemes have proposed to use this plan. Figure 1 is typical; it shows the apparatus looking through its lens-eye at a box flooded with light by two intense lamps at the side. By means of the lens an image of the box is formed on the rotating disc, and as one of the apertures moves across the image, light passes through onto the photoelectric cell behind. Current from the cell is therefore a continuous record of brightness of the parts of the image passed over by the successive apertures. Meanwhile the lamps are sending out rays in all directions, and that small area of the box, whose image just fits the aperture at any instantaneous position of the disc, is itself scattering in all directions the light which it receives. It is of course only the rays directed through the aperture that produce a current. The light reaching the photoelectric cell at any instant is therefore very small even when the object is brightly illuminated, for of course only a tiny fraction of the light from the lamps falls upon the particular area "seen" at any instant.

Of the light falling upon the area under consideration, part only is so reflected that it reaches the lens; the remainder is lost to the television apparatus. Quite evidently the portion of the light collected depends on the area of the lens. Physical difficulties prevent increasing the diameter of the lens, with respect to its focal length, beyond a certain ratio. When this ratio is reached a further increase in lens area means a larger image, and therefore a larger rotating disc to scan it. Mechaical limitations of the size of the disc therefore impose a limit on the size of the television eye.

These two restriction are particularly serious on account of the small currents to be secured from light-sensitive cells. A photoelectric cell of the usual type, with an opening an inch in diameter, will give a current

of a millionth of an ampere when a twenty-five watt lamp is burning about four feet away. But television must operate with far less light than that; roughly, it has available only the feeble light reflected from an area approximately the size of a finger tip.

Then there is the "ghost" of television, which haunts the system with its phantom snowstorm. The reason is that the current from the cell must pass through a resistance to produce the voltage drop by which the first amplifier tube is operated. In this resistance, as in any piece of metal, the electrons are constantly in a state of swift, random motion, giving minute but rapidly changing differences in voltage between the ends*. The amplified current fluctuates correspondingly and, if it has been magnified sufficiently to make the fluctuations large, gives the effect of a snowstorm on the screen at the receiving end. If, however, the object can be lighted brightly enough, the output of the cell will be great enough to override the random fluctuations from the resistance, much as a powerful broadcasting transmitter overrides static.

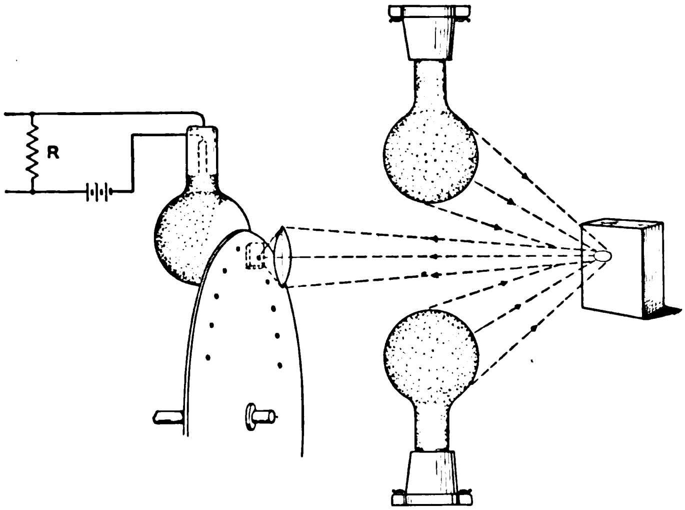


Figure 1—*A television system in which the object is broadly illuminated*

In order to secure the effect of an intense illumination without inconvenience to a subject, our apparatus resorts to sight by a method in accordance with ancient philosophy, and thereby makes rather startling gains in effectiveness. The entire optical system is reversed, with the light starting from what has previously been visualized as its destination. The rays from an arc lamp are condensed so that they converge on a small area on the back of the rotating disc. As one of the apertures passes across the illuminated area, a pencil of light passes through and is focussed on the box by a lens. The box is thus traced over by the moving image of successive apertures of the disc: in effect, by a spot of light moving in a series of adjoining parallel stripes. After striking the box the light is reflected in all directions and some of it enters large photoelectric cells placed where the flood lights had been imagined to be in the previous arrangement. The result in television operation is the same as if the whole object were continuously illuminated. The moving beam coming from successive apertures of the scanning disc illuminates at any time the only area whose light can be used. At the same time there is no inconvenience to the subject; al-

* *These random voltage variations were discovered by J. B. Johnson.*

though the intensity of the spot is high, the average intensity over the field is low.

A second gain comes from liberation of the apparatus from its former limitation: the size of lens available. The light reflected from the subject is collected directly by giant photoelectric cells developed for that special purpose and used in a system permitting several to be operated in parallel. The three cells of an actual television apparatus present an area of 360 square inches to collect light, instead of a possible seven square inches of lens that could be used to form an image on the fifteen-inch disc.

By these gains in efficiency, the photoelectric current is increased to an average value of a ten-billionth of an ampere—a current extremely small, but well beyond the range of interference from random fluctuations which which may occur in the resistance.

In the two methods of operation mentioned, the light passes in opposite directions over identical paths. A natural question is whether the increased sensitivity of the system has been at the expense of perspective or truthful reproduction. That happily is not the case to even the slightest degree. It appears to be a general law of optics that when light striking a surface has a particular fraction of its energy reflected in any direction, then light passing back over the reflected path has the same fraction of its energy turned back to the original direction. The flow of energy for any position of the scanning disc is therefore of exactly the same character in one direction as in the other.

Utilizing this principle, we can secure lighting effects by placing the photoelectric cells symmetrically around the object as if they were lamps. The light, coming from the front, is of course scattered in all directions but it can be caught only where cells are available. If these are on one side only, light reflected from the opposite side of the object would be lost, and the effect on the received image would be to leave that side in darkness. In addition each cell catches a considerably larger part of the light coming from the nearer part of the object than from the farther part, just as a lamp illuminates bodies close to it more strongly than those further away. The apparatus therefore "sees" the object as if it were illuminated by the photoelectric cells.

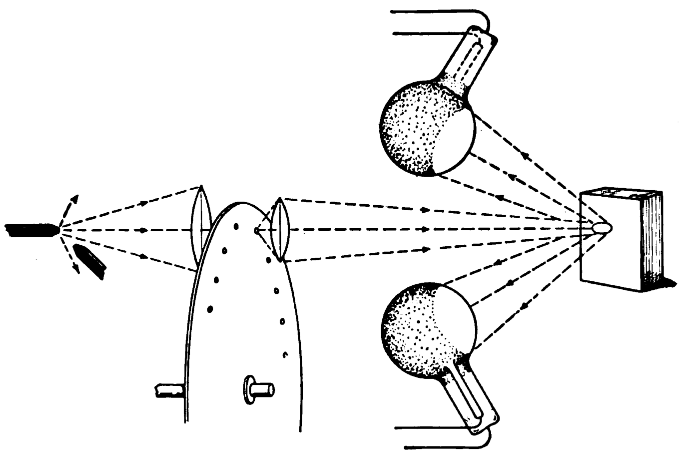


Figure 2—In this system the object is scanned by an intense beam of light

To be consistent in operation and to assure truthful reproduction as well, the apparatus should be blind to all illumination not coming from

its own eye. This might be secured by having no other illumination in the transmitting room, but actually it comes about as a result of the electrical circuits used in transmission. These necessarily amplify and transmit the fluctuations of the photoelectric current, but not the steady value about which the fluctuations occur. Uniform increase in brightness over the entire field results in an increase in the steady current from the cells and in a shifting of the fluctuations, practically unchanged, up to a higher current range. The fluctuations will be amplified and transmitted, and the direct current rejected, as before; the received image will consequently be the same whether transmission takes place from a darkened room, or from one well lighted.

Having intimated that the over-all brightness of the transmitted scene has no effect on the received image, a natural question is, "What is the relation between the two and how is it controlled?" Experience with ordinary photography answers the first question: there is none. A twilight scene when photographed may yield a picture as brilliant as if the sun had been shining. Actual practice is to adjust the brightness of the arc lamp to secure optimum conditions at the transmitter and independently to adjust the circuits at the receiving end.

An interesting case is that met when the subject is smoking. Those who have not seen this demonstrated frequently ask, "What does the glowing end of a cigar look like at the receiving end?" The answer, curiously enough, is, "Black", as long as the light from the red-hot carbon acts continuously on the cells, adding its own steady component to the output. As the amplifier is not responsive to direct current, this illumination does not register at the receiving end. When the scanning point of light passes over the glowing carbon, it is reflected just as it would be from a dead coal—that is, the cigar tip looks black to the photoelectric cell, and therefore it looks black to the observers at the receiver.

Amplifier for Condenser Transmitter

H. C. CURL
Apparatus Development Department

CONDENSER transmitters have two principal advantages over the older carbon button type, which have made them invaluable not only as laboratory precision instruments but for the electrical recording of phonograph records and the talking motion pictures. Their electrical output follows much more faithfully the sound input over a very wide frequency range than does that of the carbon tranmitter, besides being free from carbon noise and difficulties due to packing of the carbon granules. Their use has been limited, however, by the two disadvantages of a high impedance and small output. These shortcomings make the use of a special amplifier necessary and for this purpose primarily the 47-A has been designed. Its circuit, shown in Figure 1, includes a vacuum tube coupled by resistance coupling to the transmitter, and an output transformer with permalloy core.

The condenser transmitter is essentially a condenser whose capacity follows very closely the pressure variations in the sound waves. When connected to the amplifier it is charged to a potential of about two hundred volts through the resistance R_1. Under these conditions it acts somewhat as an alternating-current generator having an internal impedance equal to that of the transmitter, which is about eighteen million ohms at thirty cycles per second and about five hundred thousand ohms at one thousand cycles. The condenser C_1 prevents the high positive potential from being applied to the grid of the tube. The proper grid bias, applied through the resistance R_2, is obtained from the voltage drop of the filament current flowing in R_3. The transmitter charging battery is used also to supply a plate potential of about fifty-five volts through the drop in resistances R_4 and R_5.

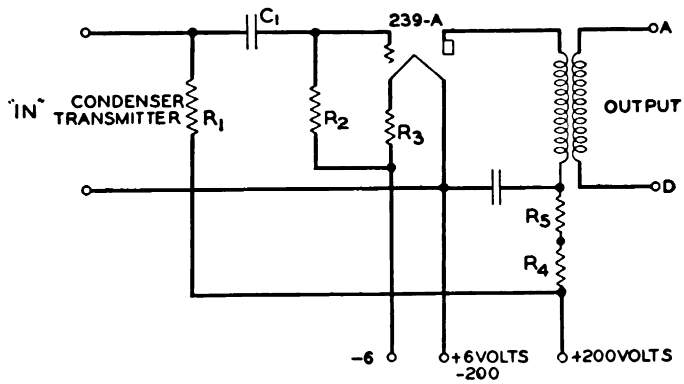


Fig. 1—*Schematic diagram of the* 47-*A Amplifier*

The grid circuit which required the most careful consideration from the design standpoint, consists of the usual resistance coupling employed in many amplifiers where high quality is required, but differs from the usual circuits in the extremely high values of resistances employed. As the voltage developed is very small, it is

desirable to impress as great a proportion of it as possible on the grid of the vacuum tube. To attain this result it is necessary that the impedance into which the transmitter is operated be high in comparison with the impedance of the transmitter at all frequencies. It was shown by computations, checked experimentally later, that R_1 and R_2 would each have to be about fifty million ohms to give an overall characteristic which would have but two T.U. less gain at 30 cycles than at 1000 cycles.

The necessity for resistances of such high values introduces difficulties both in obtaining reliable resistances and in the operation of the circuit. The resistances employed in the 47-A amplifier consist of a liquid known as xylol which is a mixture of xylene and alcohol. Contact with the liquid is made by platinum wires sealed into the ends of the small glass tube that contains it. These resistances were chosen on the basis of their small size, stability, and quietness.

With a high resistance in the grid circuit of the vacuum tube certain factors ordinarily neglected must be considered. Referring to the circuit of the amplifier, it will be seen that a current may flow from the positive of the two hundred volt battery supply through resistance R_1, the insulation resistance of condenser C_1, and back through R_2 to the negative of the battery supply. Another leakage path is from the plate of the vacuum tube through the vacuum tube base and socket and through R_2 back to the negative of the battery.

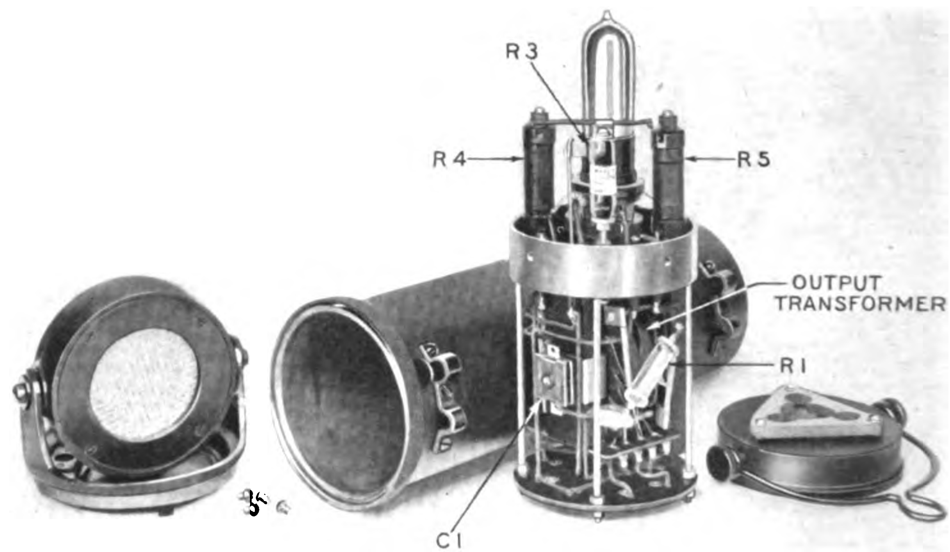


Fig. 2—The 47-A Amplifier assembly with the containing shell and the condenser type transmitter

The effect of these leakage currents is to cause a voltage drop in R_2 which subtracts from the applied

grid bias. Five hundredths of a micro-ampere is sufficient to cause a change in the grid voltage of two and a half volts which would cause a very noticeable distortion. A leakage current of this value would be obtained with an insulation resistance of four thousand megohms across condenser C_1 which is considerably higher than the usual requirement placed on condensers. Condenser C_1 therefore must have unusually high insulation resistance which for the condenser employed is approximately fifty thousand megohms. The insulation resistance between the grid and plate of the vacuum-tube base and socket is made correspondingly high.

The maximum voltage cannot be obtained from the transmitter merely by making the grid resistance high, since there remains the input capacity of the tube which also limits it. For this reason it is advisable to employ a tube with an input capacity small compared to that of the transmitter. Capacity between the leads from the transmitter to the amplifier and between the wires in the amplifier also has the effect of reducing the voltage reaching the grid so that this capacity must also be reduced to a minimum by placing the transmitter as close to the amplifier as possible. This arrangement eliminates also the interference which long transmitter leads would pick up.

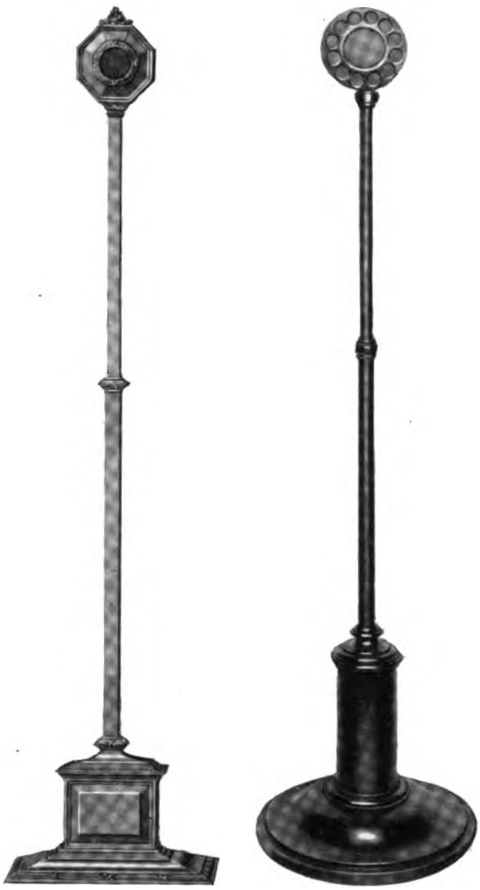


Fig. 3—Decorative floor-stand models designed by G. R. Lum

The requirement of high resistances and low capacity in the grid circuit necessitates extreme care in the design of all parts of the amplifier and of the mechanical arrangement of the apparatus, to eliminate low insulation leakage paths and losses due to shunt capacity. The vacuum tube employed is the 239-A. It consists of elements similar to those of the 215-A tube but mounted in a larger structure to increase the insulation resistance between the tube elements. These tubes, in addition to the usual tests, are subjected to a special ionization and insulation-resistance test, and to other tests to insure that they are non-microphonic.

The 47-A amplifier is shown disassembled in Figure 2. The ampli-

fier unit fits into the metal shell shown, which measures about three and three-quarters inches in diameter by eleven inches long. The transmitter housing is fastened to one end of the shell by a clamping ring which engages with the threads on the base of the housing. By releasing the clamping ring the transmitter housing may be turned approximately 360° or removed altogether to make connections to the terminal plate of the amplifier. The transmitter itself is held in a cradle pivoted as shown, which permits rotation of about 90°. These two adjustable rotations allow the transmitter to be turned to face the source of sound regardless of the position of the amplifier.

This type of amplifier is designed to be suspended in the air, either by the two lugs shown on the side of the shell, or from the handle at one end. The small diameter of the amplifier, which is but little greater than that of the transmitter itself, provides a unit which is not objectionably large when placed in a conspicuous place, such as is often necessary in picking up material for broadcasting or recording. This small size of the unit is especially advantageous in the recording of talking moving pictures, because it permits easy concealment from the lens of the camera.

The main supporting element of the amplifier assembly is a circular brass casting. On one side of this casting the vacuum-tube socket and three resistances are mounted and on the other side the output transformer, the grid circuit resistances and condenser, and the terminal plate. After the apparatus is wired this assembly is dipped and impregnated under a vacuum with an insulating varnish to protect the apparatus from the effects of high humidity. This assembly may be mounted in floor types of stands such as shown in Figure 3 for use where this type of mounting is preferred.

A Large P. B. X. Installation

An unusually large private branch exchange has recently been put into service for the Consolidated Gas Company of New York. It has forty-two positions, with a present installation for 2300 extension lines and 520 trunk and tie lines. About six million calls a year are now being handled. The board is of the No. 1 Type, but equipped with circuits of the 604-C Switchboard arranged for operation with the dial system. The power plant includes two motor-generator sets and a 210-ampere storage battery.

Terminal Strips

By E. S. SAVAGE
Apparatus Development Department

OF the evolution of terminal strips into their present form comparatively little is known. It is certain, however, that the strips have undergone less change during the past thirty-five years than almost any other apparatus in the telephone plant. A study of Patent Department records and old photographs of central offices shows that terminal strips of practically the same general design as those still in service were used at least as early as 1892.

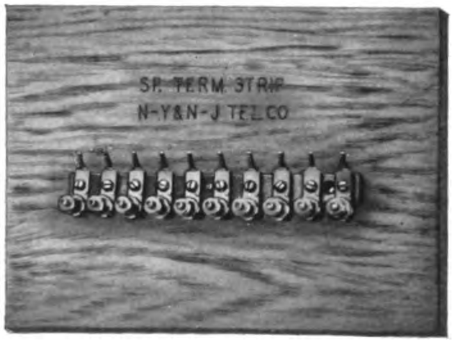


Fig. 1—An early terminal strip, drawn from an old photograph. This was probably used at a switchboard

Terminal strips became important when the main distributing frame was patented by Angus S. Hibbard in 1891. Previously, as is set forth in the patent, lines entering a central office had been distributed without order, by means of connecting wires running in the shortest paths from the ends of the cables to the switchboard terminals. This older method involved such extensive crossing of the wires that they became inextricably interlaced, and moving or withdrawing any of them for testing, redistribution, or any other purpose could be accomplished only with the greatest difficulty.

It is probable that some sort of terminal strip was in use at the switchboards even during this earlier period to permit permanent wiring of the jacks, so that there would be no need for entering the switchboard to make changes in wiring. There is in the files an undated picture of an old terminal strip, used at one time by the New York and New Jersey Telephone Company, which looks as if that were its purpose. Its terminals are fitted with screw binding posts at one end and soldering lugs at the other. A still earlier type, with screw binding posts at both ends of the terminals, is shown in a patent filed in 1890.

As at present designed, the great majority of terminal strips are of the general type shown in Figures 2 and 3. Figure 2 is a fifty-circuit terminal strip for terminating trunk and miscellaneous cross connections on the horizontal side of the main distributing frame. Figure 3 represents the more usual twenty-circuit terminal strip of the type used in switchboard sections and desks. Terminal strips of this general type are used on horizontal and vertical sides of the intermediate distributing frame, on the various frames for dial equipment and on relay racks. There are some eighty-odd coded varieties of terminal

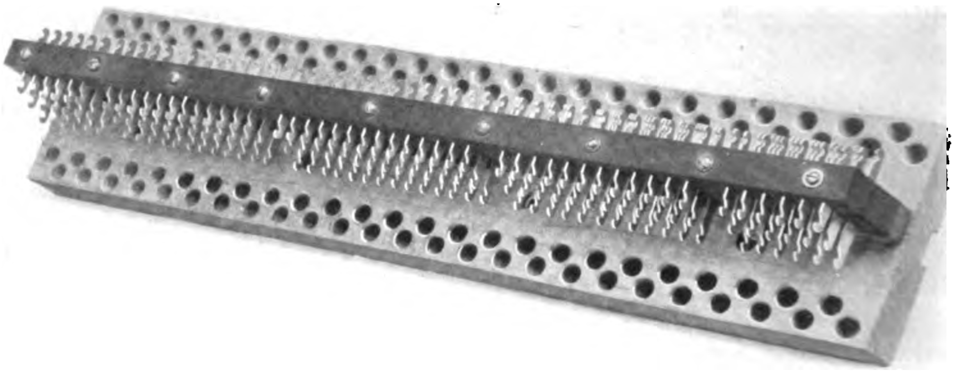


Fig. 2—*No.* 183 *terminal strip*

strips of this general type providing for various combinations of from ten to fifty circuits and three to eleven terminals per circuit. Each of these terminal strips is made with a base of hard maple, perforated with holes through which the wires are drawn. In practically all cases a hole is provided on each side of the base for each vertical row of terminals. By passing the wires through these fanning holes, as they are called, an orderly distribution of the wires to the various terminals is accomplished, and in case of trouble the tracing of the wires is made much easier. On top of each base is a wood strip called the bottom strip, and above this there are a number of mounting strips of hard rubber, usually three or more, slotted to carry the terminal punchings. Above is a top strip of hard rubber, and in some cases this is surmounted by a wooden designation strip. The entire pile-up is clamped together with long machine screws, fastened into threaded holes in a narrow steel strip lying in a groove on the lower side of the base. The terminal punchings themselves are stamped from sheet brass and coated with tin, and are of several lengths. They are held in parallel rows in the slots of the mounting strips, with the longest on the bottom in order to facilitate soldering.

Another type of strip, used for terminating subscribers' lines on main distributing frames, is No. 65. The base is irregular in cross section, with an upper edge overhanging the terminals to protect them from crosses which might be caused by solder or other material falling from above. Only one mounting strip is used, fitted with three-armed punchings having three soldering terminals; of these, one comes above the mounting strip,

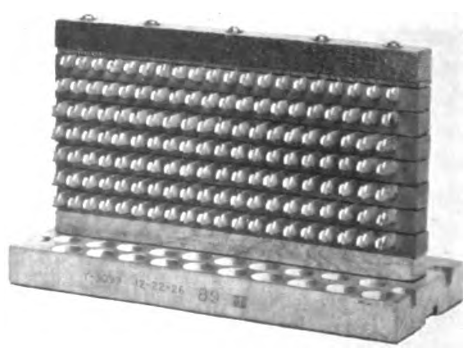


Fig. 3—*Strips of this type have as many as eleven rows of terminals*

which is horizontal, and the other two below. In general, according to current practice, the cable pairs from the outside terminate on the vertical side of the main distributing frame. From there they are connected by jumper wires to the upper terminals of the No. 65 strips, which are on the horizontal side of the frame, and from the lower terminals, switch-board cables run to the intermediate distributing frame. Should a subscriber move to another location within the same central office area, or should a new cable be installed, it would be desirable to change his line from one cable pair to another without changing his telephone number. In such a case the usual procedure is to move the connection of the jumper wires from the upper lugs to the middle lugs of the same punchings, and then to connect jumpers from the new cable pair to the vacated upper lugs. Thus the subscriber has a connection to both cable pairs

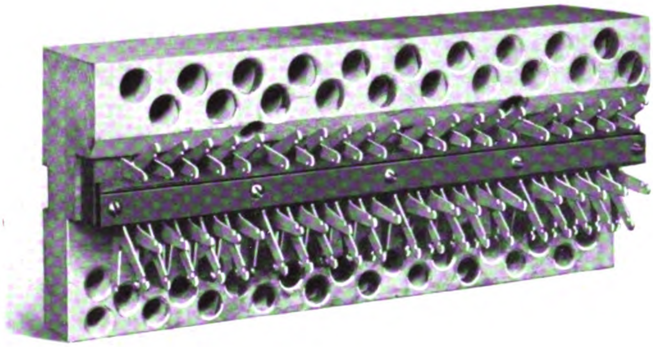


Fig. 5—No. 65 terminal strip. Staggering of the punchings permits closer spacing

involved. When he moves or when the new cable is put into service, the old jumpers are cut off at the terminals and pulled out.

Quite recently terminal strips of this design have been produced with the punchings mounted closer together than in the No. 65 type, so that fifty cable pairs can be terminated in the space formerly occupied by forty. Since new and old strips can be mounted interchangeably, the result is a twenty per cent increase in capacity of the horizontal side of a main distributing frame of any particular size.

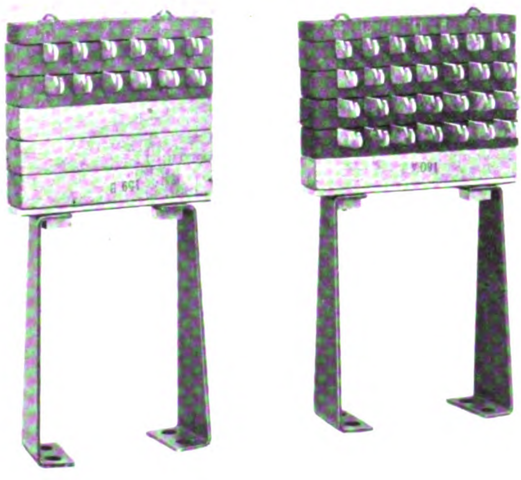


Fig. 4—Two strips fitted with metal brackets for mounting on panels

In addition to these terminal strips of regular type, which differ from each other principally in the length

of the base, number of punchings per row, height of the pile-up, and other details, there are many modifications of the standard designs. Among these are strips with only half the usual base, others without any base, strips with the pile-up mounted on small metal brackets, and still others quite unlike terminal strips in appearance; in one of these, used for terminating the wires to translators, the lugs are of such lengths that their ends form a concave arc. These special designs constitute in all less than a twentieth of the strips made each year.

In the number of piece parts required annually, terminal strips are probably near the head of the list of telephone apparatus. More than four hundred thousand strips of all sorts are manufactured each year, and these require no less than forty-eight million punchings. Each punching in turn uses at least two soldered connections for installation of the original wiring, or a total of about a hundred million for a year's output. Other millions — possibly dozens of millions — of soldered connections are made each year by Associated Company men on account of moving by subscribers and rearrangement of facilities. It is therefore evident that the design of such pieces of apparatus is most important from the standpoint of installation and maintenance.

"To Have and To Hold"

SINCE 1920, the market value of A. T. & T. stock has climbed steadily from about $100 per share to twice this value. To those who during this period purchased stock under the Employees' Plan and who have held it after it was paid for, this increase in market value brings a pleasant reward. To those who failed to take advantage of the plan or who disposed of their holdings, it is likely to be the subject of equally keen regret.

There are many different ways of stating in figures just how advantageous the stock purchase plan is. The following form of statement does not pretend to be unique but it does emphasize certain important features which may not be generally realized.

The ultimate aim of every savings plan is to provide a competence for later years. It is generally recognized that any such plan should be systematic and of course should effect the growth of principal as rapidly as possible. These conditions are met by setting aside a certain sum of money at regular intervals to draw interest and by reinvesting the interest so that it will be compounded. The higher the rate of interest at which one is able to invest his funds, the more rapidly does the principal grow.

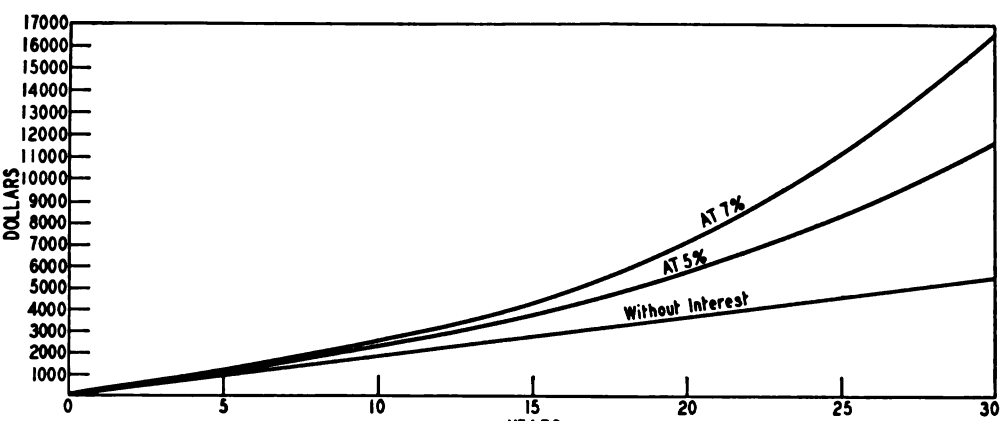
The present plan under which we may purchase stock is dated May 1921. Let us, therefore, calculate the savings of a member of the Laboratories who decided at that time to invest $15 monthly toward the purchase of stock, and commenced payment July first. His first five shares of stock would have cost him $100 per share and would have been paid

up in January, 1924. Resubscribing for five more at $118 per share, he would have had these fully paid for in January, 1927. His next subscription would have been for five more shares at $130. Although the total of his monthly installments amounts to $1237, the value of these plus interest and dividends amounts to $1605. However, if the present market value of his ten shares which are paid for is taken into account, the value of his savings is actually about $2590. Restating this last figure in terms of a single rate of compound interest, holding throughout the period from July 1921 to the present date, we arrive at a startling result: had this same individual begun in 1921 to lay aside $15 a month, he would have had to obtain the extraordinary return of 24% compound interest in order to have today what the Employees' Stock Plan has provided him.

Another interesting comparison can be made. Payments of $15 per month deposited in a savings bank at 4% annual interest compounded quarterly would come to $1,453 at the end of 7 years; the present value of the savings under the stock plan exceeds that sum by $1230. This surplus has accrued to the employee in question over a period of 7 years, and therefore represents an average annual gain of $175. If we assume that he subscribed to his full quota of stock, his annual salary must have been between $1200 and $1500. In other words, by subscribing he has been able, just for the asking, to increase his yearly income by an amount equal to about 12% of his salary.

It is by no means the present intention to imply that benefits to the participant under the stock purchase plan will over a long period of years show such striking opportunities. Nevertheless the plan will certainly continue well worth subscribing to.

Now that the market value of the stock has reached a new high for all time, many holders are beginning to wonder whether or not they should sell and thus "realize" their profit. In the case of our hypothetical employee who now has ten shares of stock fully paid for, this means the exchange of these ten shares for about $2000 in cash. Immediately, the problem of reinvesting the $2000 has to be found. Safety of investment is the first consideration and satis-



Accumulation of $15 saved each month, with and without compound interest

factory yield second. The combination of these two features in a single investment is now notoriously hard to find. Many good bonds yield little better than 4% and some of the best common stocks even less than this. Let us contrast this situation with the other alternative of holding the ten shares of A.T.&T. stock. Each share is paying $9 per year dividend and during the period beginning in 1924, when the first shares were fully paid up, each share has been granted rights whose value averaged over six years has amounted to $4.05. Every share has, therefore, actually returned to its owner $13.05 a year which on the *present market value* of the stock represents a yield of 6.5%.

Again a definite statement as to the future is impossible, but we all know that the growth of the American Telephone and Telegraph Company is destined to be very rapid and that it is the stated policy of the management to raise much of the new money required to finance growth by issuing rights for the sale of new stock to stockholders. The advisability of selling our A.T.&T. stock, even at the present prices, therefore seems doubtful.

SUBSCRIPTION TO A. T. & T. STOCK

Payments July 1, 1921-*June* 30, 1928 *on five shares of stock*

First group of shares at $100	$500.00	
Less interest credited on payments	47.70	
Net payments		$452.30
Second group of shares at $118	$590.00	
Less interest credited on payments	60.30	
Net payments		$529.70
Current group, 17 months at $15 per month		255.00
Total payments		$1,237.00

Approximate value of holdings July 1, 1928

First group 5 shares at $188*	$940.00	
Second group 5 shares at $188*	940.00	
Third group Payments unfinished. Equity $53.59 per share	267.95	
Dividends received:		
17 dividends on first group of 5 shares	$191.25	
5 " " second " " " "	56.25	
Average market value of rights received:**		
5 rights May, 1924, at $3.68	18.40	
5 " May, 1926, " 6.12	30.60	
10 " May, 1928, " 14.50	145.00	
Value of stock and returns	$2,589.45	

* *Value, ex rights, at market close May* 31, 1928.

** *These figures show the account as it would have stood had the rights been sold. Had the employee exercised his rights using accumulated dividends, and perhaps, arranging a loan at his bank which future dividends would liquidate, the profit he would have derived from his rights would, of course, be considerly greater than the market values shown.*

News Notes

AMONG guests at a banquet tendered by All America Cables, Inc., to celebrate its fiftieth anniversary, were Edgar S. Bloom, Bancroft Gherardi and W. F. Hosford, Directors of the Laboratories; E. B. Craft, Executive Vice-President and E. P. Clifford, Vice-President.

MR. JEWETT addressed the engineering faculty and students of Princeton University on May 1 on the subject of "Cooperative Research." On April 26 Mr. Jewett spoke on "The Development and Use of Radio Telephony as a Means of Communication" before the Harvard Graduate School of Business Administration.

MR. CRAFT and his staff entertained the Division of Engineering and Industrial Research of the National Research Council at a luncheon meeting on May 4, Mr. Elmer Sperry, President of the Sperry Gyroscope Company, presiding. Afterwards the visitors viewed a demonstration of television and the talking movies.

MR. CRAFT spoke on "Research and Its Relation to Industry" before the Connecticut Chamber of Commerce at Hartford on May 17.

THE ELLIOTT CRESSON MEDAL was presented to Gustav W. Elmen by the Franklin Institute on May 16. Award was for "extended researches in the magnetic characteristics of nickel-iron alloys resulting in Permalloy."

Among other workers in the communication field to whom the Elliott Cresson medal has been awarded are Dr. Alexander Graham Bell, for the electrical transmission of speech; Dr. Michael I. Pupin, for loading of telephone lines, the American Telephone and Telegraph Company for contributions to the telephone art, and Dr. Lee De Forest, for the three-element vacuum tube.

AT THE COLLOQUIUM meeting on April 30 Professor J. Franck of Göttingen, spoke on "Collisions of the Second Kind". On May 15 E. U. Condon of Columbia University brought out a number of applications of the utility and power of wave mechanics in dealing with certain current problems of physics.

APPARATUS DEVELOPMENT

F. A. KUNTZ visited the New England Telephone and Telegraph Company in Boston to investigate operation of No. 392 type loud ringing bells.

H. T. MARTIN AND O. A. SHANN visited the Gray Telephone Pay Station Company at Hartford, Connecticut, to discuss upper steel housings and locks for coin collectors.

E. L. NELSON addressed the Philadelphia Section of the Institute of Radio Engineers on April 27 on "Recent Improvements in Radio Broadcasting Apparatus."

D. H. NEWMAN supervised the installation of a one-kilowatt broadcasting equipment for the Universal Broadcasting Company in Philadelphia.

E. L. NELSON AND H. S. PRICE

made a survey for the installation of a fifty-kilowatt broadcasting equipment for the Crosley Radio Corporation in Cincinnati, Ohio.

W. L. Tierney has been in California where he made a survey for a one-kilowatt broadcasting installation for Nichols and Warinner at Long Beach. He also inspected the stations of Warner Brothers at Hollywood, Pasadena *Star News* at Pasadena, and Tenth Avenue Baptist Church at Oakland.

D. H. Gleason visited New London, Connecticut on April 24 to observe the operation of step-by-step switches installed there.

H. B. Arnold attended the Regional Meeting of the A. I. E. E. at Baltimore on April 19 and 20.

C. F. Boeck has been engaged since April 12 in testing the power line carrier equipment which is now being installed on the Pacific Gas and Electric Company's lines between Claremont, Vaca-Dixon and Pitt River by R. D. Gibson and C. N. Nebel.

G. C. Porter visited Philadelphia on May 3 to inspect alternating current motors to be used with talking motion pictures.

F. F. Lucas has been elected Chairman of New York Chapter of the American Society for Testing Materials for the coming year.

H. O. Siegmund presented a paper on electrolytic condensers before the meeting of the American Electrochemical Society in Bridgeport, Connecticut, on April 27. J. H. Bower and J. C. Wright were also present.

E. B. Wheeler visited the Bureau of Standards in Washington on April 26 to consult with Dr. Vinal regarding dry cell work.

J. R. Townsend has been appointed Chairman of a special committee on hardness testing of the American Society for Testing Materials.

J. R. Townsend and H. A. Anderson attended the meeting of the Committee on methods of testing of the A. S. T. M. at Philadelphia on April 27.

J. M. Wilson and J. D. Cummings visited the Siemen Rubber Company, Bridgeport, Connecticut, on May 4.

H. A. Anderson was in Southington, Connecticut and Phillipsburg, New Jersey in connection with the manufacture of linemen's climbers.

Inspection Engineering

R. L. Jones, D. A. Quarles, H. F. Dodge, W. A. Shewhart, O. S. Markuson and P. S. Olmstead represented the Laboratories at a series of conferences held at Hawthorne during the week of April 16. They discussed application of statistical methods to product, and inspection problems on lead covered cable and telephone instruments.

D. A. Quarles and S. H. Anderson were at the General Electric Company's factory in Lynn, Massachusetts, the week of April 23 for a survey conference on "P" type ringing and coin control generators.

S. H. Anderson visited the Buffalo Gasoline Motor Company at Buffalo on April 18 to discuss standardization problems of type "ATT" emergency gasoline engines.

E. G. D. Paterson and C. D. Hocker visited the R. H. Buhrke Company at Chicago on April 13 and 14 to examine processes in manufacturing body belts and safety straps.

E. G. D. Paterson was in Boston on May 10 and 11 discussing prob-

lems involving extension ladders with engineers of the New England Telephone and Telegraph Company.

O. S. Markuson visited the Chemung Telephone Company at Sayre, Pennsylvania on May 9 to observe a cable installation.

H. G. Eddy and R. M. Moody attended regular Survey Conferences at Hawthorne during the latter part of April and the first part of May. H. F. Kortheuer and T. Mellors were in Kearny and W. C. Miller was in Philadelphia during the same period attending similar conferences.

A. G. Dalton, formerly of the General Installation Engineering Department of the Western Electric Company, has been transferred to the Inspection Engineering Department. Mr. Dalton will have charge of the Field Activities Groups of the Systems Inspection Department.

W. E. Whitworth has been appointed Field Engineer in the territories of the Northwestern Bell Telephone Company and The Mountain States Telephone and Telegraph Company, replacing J. M. Schaefer. Mr. Schaefer is returning to New York for a special assignment in field engineering work. Mr. Whitworth's headquarters will be in Omaha.

R. J. Nossaman visited Chicago, Omaha and Denver during May in connection with work of the field engineering group.

J. A. St. Clair, Local Engineer at Atlanta, visited Macon, Georgia and several cities in Florida during April in connection with regular field work in his territory.

Outside Plant Development

R. L. Jones, S. C. Miller and J. A. Carr made studies of outdoor testing facilities for development work in Phoenixville, Pennsylvania on May 1.

L. W. Kelsay visited Bridgeport, Connecticut on May 9 in connection with development studies on molded insulating materials.

C. D. Hocker visited Pittsburgh, Altoona and State College, Pennsylvania and Sandy Hook, New Jersey between April 30 and May 3 to examine zinc coated sheet products being tested by the American Society for Testing Materials.

F. F. Farnsworth attended the Spring meeting of the American Electrochemical Society in Bridgeport, Connecticut on April 27 and 28.

W. T. Hervey visited Providence during the early part of May in connection with development studies on insulators.

Systems Development

L. Earl spent several days at Monticello and Catskill, New York, making noise tests on the power plants prior to the cutover of new No. 11 switchboards.

H. M. Pruden spent the last of April in Chicago testing 1000 cycle signalling equipment in the Long Lines Offices of the Illinois Bell Telephone Company.

G. E. Sohnle and J. E. Cassidy arranged for the installation of an automatic carrier pilot channel system between Washington, D. C. and West Palm Beach, Florida. G. H. Huber, D. M. Terry and W. F. Kennenberg are conducting tests at various stations along the line.

H. J. Fisher has returned from London, England, where he has been making tests on transatlantic radio equipment.

W. M. STUART was in Boston April 9 to 11 investigating subscribers' ringing conditions.

G. R. VERNON visited the new step-by-step office at New London, Connecticut on April 23 and 24.

J. IRISH spent the last week of April at Hawthorne to promote closer relations between drafting practices of the Laboratories and the Hawthorne Works.

C. A. SMITH AND L. P. BARTHELD visited the new Cleveland Toll Office in connection with tests and studies on toll equipment.

A. E. PETRIE AND V. T. CALLAHAN were in Buffalo April 17 and 18 testing a new 6 cylinder Buffalo gasoline engine.

J. L. LAREW AND H. KEPPICUS visited the toll offices at Utica and Syracuse to make noise tests in the repeater equipment.

RESEARCH

H. H. LOWRY made two visits to the coal fields in the neighborhood of Wilkes Barre from April 18 to 20 and from April 24 to 26.

B. L. CLARKE AND K. K. DARROW attended the Spring meeting of the American Chemical Society held at St. Louis, April 15 to 20.

R. M. BURNS, C. L. HIPPENSTEEL, C. A. KOTTERMAN, L. E. KROHN, A. G. RUSSELL AND J. V. VOORHEES attended the Spring meeting of the American Electro-Chemical Society held in Bridgeport, Connecticut, from April 26 to 28.

W. C. ELLIS was at Hawthorne from March 31 to April 23 in connection with metallurgical work which is being carried on out there.

C. H. G. GRAY sailed May 12 on the Majestic for a three months stay in Paris where he is to supervise the installation of the European Master Telephone Transmission Reference System which is a replica of the American System adopted a year and a half ago. The European Reference System is to be installed in the Conservatoire Des Arts and Metiers under the jurisdiction of the Comite Consultatif International Des Communications Telephoniques a Grande Distance.

J. B. KELLY AND R. L. WEGEL attended a meeting of the American Otological Society in Washington on April 30 and May 1.

R. M. BURNS, with F. F. Farnsworth of Outside Plant Development, discussed the corrosion of cable sheath in concrete conduits before a regional meeting of the A. I. E. E. at Baltimore on April 18.

J. A. BECKER was elected a Fellow of the American Physical Society on February 28 and a Fellow of the American Association for the Advancement of Science on April 22.

R. W. WATERMAN was in Gulfport, Mississippi, from April 8 to 26 in connection with the study of wood preservation now being made in conjunction with the Gulfport Creosoting Company.

H. FLETCHER visited the Southern Bell Telephone Company in Atlanta in connection with his work on audiometric problems.

A LARGE DELEGATION from the Laboratories attended the two recent scientific meetings held at Washington: the annual meeting of the American Section of the International Union of Scientific Radio Telegraphy held on April 19 and the Washington Meeting of the American Physical Society held from April 20 to 21. At the former meeting J. W. Horton and W. A. Marrison presented a

paper on "Thermostat Design of Frequency Standards" and H. T. Friis gave the general report of the Chairman of the Committee on Atmospherics. At the meeting of the American Physical Society, there were papers by R. R. Riesz on "Differential Intensity Sensitivity of the Ear", C. J. Davisson and L. H. Germer on "The Refraction of Electrons by a Crystal of Nickel", J. M. Eglin on "Thermionic Activity, Evaporation, and Diffusion of Barium in Tungsten", T. C. Fry and H. E. Ives on "The Voltage Current Relation in Central Cathode Photo-Electric Cells", and H. E. Ives, A. L. Johnsrud and A. R. Olpin on "The Distribution in Direction of Photo-Electrons from Alkali Metal Surfaces". H. E. Ives also gave an after-dinner talk on "Back Stage in Television" before the American Physical Society.

R. M. Burns opened the round table discussion of "The Corrosion of Lead Cable Sheath" at a meeting of the New York Section of the American Electrochemical Society on May 18.

L. H. Germer addressed the New York Microscopical Society on "The Diffraction of Electrons" on May 4.

General Staff

S. P. Grace spoke on inverted speech and recent discoveries and inventions of the Laboratories before the Dayton Engineers' Club at Dayton, Ohio, on May 8, the Western Society of Engineers in Chicago on May 14, the Pennsylvania State Telephone and Traffic Association at Harrisburg, on May 16, and the Up-State Telephone Association of New York at Rochester, on May 24.

G. F. Fowler gave a talk on liquid air and a demonstration before a group at Pioneer Lodge, 70, F. & A. M., Hackensack, on Friday evening, May 1.

R. A. Deller spoke before the Students' Training Class of the New York Telephone Company on April 28, on the subject of television.

R. W. King addressed the Engineers' Society of Milwaukee on May 16, and the Electrical League of Milwaukee on May 17, on television.

"The Magic of Communication" by John Mills is one of the selections in a volume of literature for junior high schools, published by Bobbs-Merrill.

Vail Medal Awards

ONE gold and five silver medals have been awarded by the National Vail Medal Committee to men and women selected from the fifty-four to whom bronze medals were awarded during 1927 by Associated Companies of the Bell System.

To be selected for National Vail Medal recognition an act must have for its objective the accomplishment of something of real value in the public interest through the medium of Bell System facilities, organization, training or experience, and must reveal to a high degree many, if not all, of the positive qualities of intelligence, initiative and resourcefulness, and usually courage, endurance and fortitude.

Outstanding service rendered during the Mississippi flood was essentially the result of group organization and effort and accordingly does not offer the opportunity for individual awards as did the New England flood where, although the group performance was equally noteworthy and outstanding, the suddenness of the onset made emergency individual action vital before group action could be organized.

Awards and Citations

A gold medal, with a cash award of $500 to Fred F. Brown, Foreman, The Connecticut Valley Telephone Company, Bradford, Vermont.

For courage, initiative and resourcefulness in restoring vital telephone service in a serious emergency, in face of grave personal danger.

When the unprecedented rains in Northern Vermont in early November 1927 had turned the rivers into torrents of destruction which paralyzed activities in that section of the state, Foreman Brown and two fellow-employees set out on November 5 to clear at least one toll line into Montpelier, the capital city, which had been isolated.

After driving twenty miles over back roads and high ground, they found that the lines were crossed where the Wells River had washed out a pole and left the tie wires tangled in the toll circuits. The cross could not be shaken out and, although the river was a rushing torrent filled with logs, trees and other debris and a fall would have meant almost certain death, Brown hooked his safety strap over the four wires and rode out on what was then a two hundred and sixty foot span, untangled the ties which caused the cross and, when one wire broke as he started back, rode the remaining three back to the pole in safety.

The circuit which he restored was immediately put into service for official use of the state authorities and was of vital importance in the organization of the relief work and in giving accurate news to the outside world.

A silver medal, with a cash award of $250, to William Foster Owens, Manager, Rock Springs Telephone Company, Rock Springs, Texas.

For initiative, courage and resourcefulness in restoring vital telephone service at a time of disaster.

In the evening of April 12, 1927, a tornado struck the town of Rock Springs, killing sixty-five people and seriously injuring many more, destroying many homes and utterly isolating the little town.

Mr. Owens saw his own house demolished and members of his family seriously injured. Leaving his family in the care of others, he proceeded to the edge of the devastated district where the toll wires were still intact. Removing the telephone from a house nearby, he climbed a pole and connected to the toll line and called Kerrville, sixty miles away, notifying them of the disaster and asking for medical aid and supplies. Through the night this telephone afforded invaluable aid in organizing and speeding the relief program.

A silver medal, with a cash award of $250, to Mrs. Clara B. Pitkin, Agent, White River Valley Telephone Company, West Hartford, Vt.

For fortitude and devotion to public service in the face of grave personal danger.

During the evening of November 3, 1927 when unprecedented rains had caused severe floods in Northern Vermont and the White River was a raging torrent, Mrs. Pitkin was on duty at the switchboard in her home on the bank of the river. She began to receive ever more urgent calls for help and, although she saw her neighbors' houses washed away by the flood and knew that her own home was in serious danger, she remained at the board, doing her best with failing lines to give all possible warning and to send help where needed. She warned all subscribers in the valley whose lines were still working and all except one family escaped.

Although she was repeatedly urged to leave, she remained until all her lines had failed and only then made her way across the road to higher ground ten minutes before the highway was flooded with rushing water. A few hours later the house was washed away by the flood.

A silver medal, with a cash award of $250, to Patrick B. McCormick, Agent, New England Telephone and Telegraph Company, Becket, Mass.

For fortitude, initiative and devotion to public service despite grave personal danger.

Unprecedented rains in Western Massachusetts early in November, 1927 had swelled the rivers and streams to torrents and it was feared that the dams in the vicinity of Becket would go out and cause great destruction. About four o'clock in the morning of November 4, when McCormick was notified that the nearest dam a mile above the town would doubtless fail, he notified every subscriber in the valley, warned them to leave, and asked them to notify those who had no telephones. He sent his own family to safety in the hills and, realizing that some of the residents would remain despite his earlier warning, stayed at the switchboard in his home, in constant telephone communication with people at the dam, to receive and transmit the final warning.

The dam went out at six o'clock and after notifying all who had remained he started warning all the towns in the path of the danger. This task completed, his escape was cut off and he was forced to remain, while houses and trees were torn up and carried past and his own home was flooded and the switchboard put out of order.

As soon the the water began to recede he climbed a pole, cut in on the toll line with his test set, and gave to the outside world the first call for relief.

A silver medal, with a cash award of $250, to Mrs. Mary Elizabeth Algor, Agent, New Jersey Bell Telephone Company, Holmdel, N. J.

For initiative, resourcefulness, persistence and devotion to public service.

While on duty in the evening of April 4, 1927, she was notified by the Central Complaint Desk in New York City that a woman whose address was Wickatunk, N. J., had purchased a prescription for eye drops in a drug store in the city but by mistake had taken away a bottle of acid. Mrs. Algor learned by inquiries that the woman was the sister of a local resident and, receiving no answer on his telephone, she called her relief operator to take her place so that she might drive to his home three miles distant. Meanwhile, however, she saved priceless minutes by calling various subscribers in the vicinity and reaching one who went to the house and reported the brother was away for the night.

Recalling that earlier in the day this brother had called another brother in New York, she located the New York brother's residence through a New York City directory, called him quickly and found that the sister was there and just about to use the acid which she supposed was the prescription for her eyes.

Mrs. Algor's resourcefulness and persistence, and her intelligent use of the telephone facilities were directly responsible for the saving of the woman's eyesight.

A silver medal, with a cash award of $250, to Horace E. Roby, Superintendent of Traffic, New England Telephone and Telegraph Company, Montpelier, Vermont.

For conspicuous initiative, resourcefulness and accomplishment in the service of the public at a time of disaster.

When on the evening of November 3, 1927 Montpelier was cut off from all communication by a devastating flood, he assisted city, state and other authorities in the initiation of measures for rescue and relief through the greatest possible emergency use of almost totally crippled telephone facilities and made unique emergency utilization of the first toll circuit to be restored in transmitting messages from the flood victims to their anxious friends and relatives.

Club Notes

The Spring Golf Tournament will be held on two Saturdays in June at the Salisbury Country Club, Salisbury Plains, Long Island, in two rounds, each consisting of eighteen holes of handicap medal play. On June 2, twenty-eight golfers will be qualified for the finals which will be played on June 9. These will be divided into two classes based on scores of the qualifying round. The fourteen low gross scores will gain entry to class A and the remaining fourteen best net scores will make up class B. The players in each class will be divided into flights of seven each. The prizes for the qualifying round will be two medals: one for low gross score and one for low net score. In the finals a first and second prize will be given in each of the four flights. The value of these prizes will be the same for each flight. In addition to the prizes mentioned, two Elgin wrist watches will be given for the low gross score in both A and B classes on June 9.



Baseball

To date the Laboratories' team in the Bell System League has been successful in all of the games played. On Tuesday evening, May 1, they defeated the team representing the Western Electric Company, 195 Broadway, by a score of ten to one, and on Friday evening, May 11, they defeated the Western Electric Company, Telephone Department, by a score of seven to four.

Admission is free to all league games and bus service will be provided if enough requests are received by the Club Secretary.



In the Interdepartmental League which opened on Saturday, May 5, with a double header, Telephone Systems Department defeated the Tube Shop and the Ringers' team composed of men from the Commercial, Research and Apparatus Development Departments defeated the Plant and Shops team.

Bell System Athletic League

At a meeting held on Wednesday, May 9, the Bell System Athletic League of New York was organized for the purpose of promoting intercompany athletics among the employees of the Bell System in the Metropolitan district. The officers elected to serve until June 30, 1929 are:

President—D. D. Haggerty, Bell Laboratories.
Vice-President—R. S. Kirkwood, N. Y. Tel. (Manhattan).
Secretary—E. H. Straus, N. Y. Tel. (Long Island).
Executive Committee—
C. Stoll—W. E. Co.—Telephone.
J. B. Stevens—W. E. Co.—Gen. Headqrs.
S. A. Henszey—W. E. Co.—Installation.
E. R. Schoen—A. T. & T. Co.

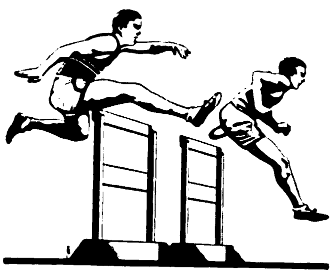
In 1926 the first Bell System Baseball League was organized and was

followed in that year by the organization of a chess league and a handball league. So successful were these activities that they were continued in 1927 and in September 1927 a basketball league of eight teams was organized.

With the start of 1928 baseball season when fourteen teams applied for admission into the league, and with the same number of them likely to apply for admission into the basketball league, steps were taken to bring all the intercompany activities under the supervision of one organization. After a careful study the athletic league was organized, whose plan it is to promote intercompany competition in baseball, basketball, chess, track, handball and bowling.

Track and Field Meet

The Bell System Athletic League will hold an Intercompany Track and Field Meet at Erasmus Hall Athletic Field, Brooklyn, on Saturday afternoon, June 16, 1928.



The program will include:

For Men

100 Yard Dash	Broad Jump
220 Yard Dash	High Jump
440 Yard Dash	Novelty Race
880 Yard Run	Mile Relay Race
Shot Put	Tug of War

For Women

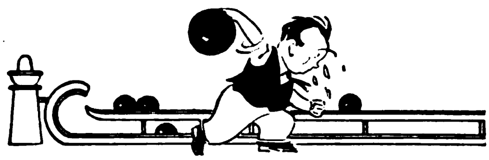
60 Yard Dash	1/4 Mile Relay Race
Basketball Throw	

Fourteen branches of the Bell System in the metropolitan district will compete in this set of games, each limited to three entries in all events but the tug of war and relay race, in which the competing organizations will enter one team apiece.

General admission will be fifty cents. Games will start promptly at 2:00 P.M. Tickets may be purchased from your Departmental Representative or in Room 164.

Bowling

The Bell Laboratories Bowling League officially closed its seventh season on April 16, with the customary bowling party which was held



this year at the Hotel Manger, and the Winter Garden. Following the dinner, for which the entire main dining room of the hotel had been reserved, Mr. Craft distributed the bowling prizes. Individual gold medals were awarded to A. Muller, J. L. Sherry, W. H. Berthold and A. G. Kobylarz.

The attendance of two hundred people at the party and the fact that all those wishing to attend could not be accommodated, indicates that interest in bowling continues to increase. Chairman Gilson in reporting on his stewardship of the bowling league affairs stated that out of one hundred and forty men, each bowling twenty-eight nights, there had been only five absentees. He also stated that the Women's Group inaugurated during the past season was proving a popular innovation and inferred that next season might see additions to the League which would make it

the largest in the Metropolitan District.

The trial season of the Women's Group, during which four teams bowled each Friday for six weeks, ended April 13. In the distribution of the season's prizes, seven individuals were rewarded: for three highest averages — Catherine Wales, Anna Wells, Florence Baker; for three highest scores — Natalie Skinner, Margaret Horne, Elsie Hacker. A prize for the greatest improvement in average was awarded to Mandy Reinbold. The team prize was won by the Pencils whose record was upheld by Anna Wells, Mandy Reinbold, Natalie Skinner, Margaret Horne and Josephine Pagano.

Glee Club

The Bell Laboratories Glee Club closed its official season on May 7, 1928, after fifteen successful weeks under the guidance of Mr. L. K. LeJeune, its professional director.

The Glee Club has planned an informal post-season program, the members meeting on Mondays at 5:10 in Room 198. Regular activities will be resumed in the fall. A cordial welcome to participate is extended to those interested in singing.

Brighton Beach Tickets

During the last three swimming seasons the Club has obtained for its members tickets for the Brighton Beach Baths at one-half the regular rate. This privilege will be available during the 1928 season to all members and their friends who wish to effect a decided saving by purchasing these tickets through the Club. Tickets for Saturdays may be had for fifty cents instead of one dollar and tickets for Sundays and holidays may be obtained for one dollar instead of two. Your Departmental Representative can supply you with as many tickets as you want.

WOMEN'S CLUB NOTES

Indoor Golf Tournament

The Women's Indoor Golf Tournament held April 10 was contested by eighteen members, a number of whom experienced their first attempt at the game. The qualifying round of eighteen holes of medal play was won by Marjorie Joseph with a score of 44. In the final round of thirty-six holes, she entered as scratch player and each of the other entrants was allowed a handicap of three quarters of the difference between her own and the scratch score. Five prizes were awarded for the best scores to Marion Mason, Natalie Skinner, Mary Crawford, Marie Boman and Marianne Grimm.

Bridge Tournament

The Women's Bridge Tournament which afforded much enjoyable competition to its participants concluded the meetings of the Bridge Club until the fall. At the close of the Tournament, on April 24, May Murtagh was pronounced winner and Edna Haunfelder second highest. The average attendance on individual nights was four tables.

BELL LABORATORIES RECORD

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By H. S. Black

PATHS OF SHORT RADIO WAVES
By H. T. Friis

JULY 1928 VOL. 6 NO. 5

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Bell Laboratories Record

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Research Methods

By FRANK B. JEWETT

Excerpts from a Talk before the Annual Meeting of the Highway Research Board, National Research Council

I IMAGINE that a large part of the population who give any thought to it think of research in the physical sciences as something new among man's activities. As a matter of fact, it is not at all a new thing. Research work in its broadest sense has been going on for centuries. Every engineering problem that was ever undertaken, which required the planning of some new thing, involved some form of research work.

There has come about within the last two hundred years a realization that to get authoritative and lasting results one has to perform experiments based on a well-considered plan, worked out from the experience of the past, and so controlled that data can be capable of definite interpretation. One of the hardest things we research people and engineers have to contend with is the temptation to draw conclusions from complex experiments or experience in terms of only a part of the factors of the problem. Even in our modern institutions and industrial research laboratories, equipped with the best means and men available, we find this tendency continually cropping up. Results are stated with a complete knowledge of only part of the factors, and sooner or later we realize that our conclusions were unjustified because of neglected factors which have played an appreciable part in the results.

Engineers and scientific people alike do this sort of thing, not consciously but unconsciously. To get a result that means anything, in most cases one must so control his investigation that but one factor is variable at a time. If you have two, it is very difficult to interpret your result as between the two factors. If you have three or more, it is practically impossible. Yet this is attempted every day, usually with the result that progress, when it comes at all, comes from doing a thing over and over again, until by statistical methods we arrive at some sort of an approximation to the truth.

There is another thing which we are very prone to do and that is to try out initial experiments on too

large a scale. Suppose you have an idea and perform an experiment on a large scale and the result does not come out as you thought it was going to; you do not know why it didn't, you do not know whether your assumption was wrong or whether failure was due to unrecognized and uncontrolled factors. Having decided what one wants to do and having made an assumption as to the correct method of doing it, he must try it out on what is essentially a laboratory scale. It has to be tried out under conditions that, so far as is humanly possible, are precisely controlled to provide only a single variable factor in a given experiment. If at the conclusion of that experiment we obtain results which are in line with our expectations, we may fairly assume that the thing we started out to do can be done, at least experimentally. We may want to repeat the experiment once or twice under other conditions to make sure of our conclusions. We are then ready to start the next part of the experiment, namely to see if we can transfer this laboratory process into a large scale operation.

I have seen experiments started on the supposition — and I am afraid I have been guilty myself at times — that certain operations can be launched at once on essentially a commercial or large scale engineering basis because they have worked on a small scale. If you can do a thing in a test tube in a laboratory under controlled conditions, you *may* be able to do it on a large scale, but not necessarily.

In order to bridge the gap between small scale and large scale experiments, our method in the telephone industry has for years followed these lines. Let us assume that the problem in hand has for its end the design of a complicated piece of apparatus. The first experiments are primarily to check up the necessary fundamental physical or chemical characteristics or reactions. We have succeeded, let us assume, in checking our fundamentals. The next step in the process is to make a piece of apparatus which as nearly as possible conforms to the ideal requirements. It is the best we can do regardless of cost. We use the best machinery and the best men and the best materials we can to make this thing an ideal piece of apparatus. Any results we obtain with it are a test, not of the fundamental principles since these have already been checked, but are a test of our ability, with the tools at present at our disposal, to make a physical thing giving certain desired results. When this carefully made sample is tested under actual operating conditions, it is a ten to one chance that certain difficulties appear which our earlier and more fundamental tests did not disclose. It means that we must make modifications if we are going to use our fundamental principles commercially.

Finally, let us suppose we have an operating piece of apparatus made under this ideal condition but which is not at all commercial. For example, this particular piece of apparatus may have cost a thousand times what we know we can afford to pay for a large number of these pieces of apparatus used commercially. We have shown, however, that the thing can be done.

The next step in the process is to build what we call tool-made models. These models conform as nearly as possible to the ideal thing but are made under commercial processes applicable to large scale production and with ultimate cost considered. Tests on tool-made models are not tests

of the fundamental thing nor of our ability to make one thing to conform to the ideal, but are tests of our ability to make in a physical, economical fashion a large number of things capable of producing a desired result.

It is only after we have gone through all three of these steps and have tried the tool-made models under service conditions and found them satisfactory that we feel safe in going into production on a huge scale and using the apparatus as a part of our standard equipment.

This general process must be gone through with in one way or another in practically every line of industry where science is applied for practical purposes.

Now, another thing. We have learned, particularly in the past thirty or forty years, that it is not always safe to neglect very small admixtures of foreign substances. This is particularly true with regard to things chemical. There was a time not so long ago when a thousandth of a per cent or a hundredth of a per cent of a foreign body in a chemical mixture was looked upon merely as an incidental inclusion which could have no appreciable effect on the characteristics of the substance. We have learned in recent years that this is an absolutely erroneous idea.

As somewhat approaching conditions of the problem which confronts you gentlemen, I might cite a situation which developed in an undertaking of the Engineering Division of the National Research Council some years ago. In connection with the problem of marine borers, teredos and the like, a study was made of substitutes for wooden structures, particularly concrete. In the course of the work, industry all over the United States and Canada and abroad became involved, and it developed from the extensive data gathered that concrete, good concrete or what people thought was good concrete, when immersed in sea water was a very variable thing. The records show that some concrete structures have stood up for an almost indefinite time, with very little deterioration. Yet right alongside of them other concrete structures, presumably made in exactly the same way, had gone to pieces in a very short time.

Investigation pointed to the conclusion that this variation was not so much due to variations in the mechanical processes of mixing the concrete as it was due to chance variation of composition in the cement, sand and stone employed. Although different cements might be nearly alike chemically, they probably reacted slightly differently when submerged in sea water, and similarly with the other ingredients. The trouble, where trouble occurred, really went back to the raw materials used in making the concrete and their chemical composition. It seemed clear that no satisfactory answer to the problem of concrete structures in sea water could be hoped for until light was thrown on the constituents of the materials.

I am citing these instances to emphasize that experience teaches us to use extreme caution. Good engineering practice must be based on conclusions drawn from controlled experiments where one variable at a time is involved, and frequently the variables are ingredients present only in greatly attenuated amount.

Finally, coming back to the problem which confronts you gentlemen, we have a situation so vast in its entirety and so diverse in its ramifica-

tions that only by some form of general cooperative attack can we hope, I believe, to make the progress which the world demands. It seems to me that sooner or later under the auspices of a group like yourselves, we must work out a scheme of cooperative research involving all of the elements required in the whole problem of road planning and road building, for in this way can we best study and evaluate the innumerable factors which enter such a complex problem.

If you are going to make conspicuous progress throughout this whole art of road building — which has become one of our largest concerns and one of the greatest needs of the country — you must, I believe, devise some very comprehensive mechanism for focusing the widely scattered knowledge and skill of the highway engineer, the chemist, the physicist, the geologist, and other scientific men in the universities and industrial laboratories. And granting that your problem is one which calls for a cooperative attack, I know of no better agency under which to bring about such cooperation than this very body of which you are a part. The National Research Council is known to be a national body without an ulterior motive of self-interest — a body designed for service along scientific lines for the population as a whole. As such its reports and conclusions carry great weight.

"The Devil Machine"

Among the many letters received at Whippany in praise of its test transmissions, is one from Mr. D. R. Gowen, Manager of the Hudson's Bay Company station at Fort Good Hope, Northwest Territories, Canada. Mr. Gowen's interest in radio reception is intensified by the fact that only four mails a year reach the settlement, and the eight white men who comprise its population depend almost entirely on programs from broadcasting stations thousands of miles away for news bulletins and information. The Indians in the radio audience find the emanations from the loudspeaker a never-ending source of awe. To them, the radio is "The Devil Machine."

A Short-Haul Carrier System

By H. S. BLACK
Systems Development Department

THE type "C" carrier telephone system is essentially a long-haul multi-channel system which will add three high-grade circuits to the facilities afforded by a single pair of wires. It is capable of operating over distances in excess of 1,000 miles, if desired, and is not infrequently economical for use on circuits as short as 100 miles. While this system thus satisfies the relatively long-haul circuit demands, there is also a considerable field for a cheaper system designed particularly for circuits between 50 and 200 miles in length. A single-channel system, the type "D", has been designed for this purpose. It can be operated over No. 12 gauge (.104) open wire lines about 135 miles long with liberal allowances for such losses as may be encountered in the toll entrance cables at each end.

Outstanding among the requirements for the proposed system as formulated by the engineers of the American Telephone and Telegraph Company were low first cost, simplified installation, minimum maintenance, good volume and fidelity of reproduction of transmitted speech, and relative freedom from all types of interference. In addition it was necessary that the new system could

Editor's Note: The definitive technical presentation of the Type D Carrier System will be made in a paper to be presented jointly by the present author, and M. L. Almquist and L. M. Ilgenfritz of the American Telephone and Telegraph Company before the A. I. E. E. at Spokane in August next

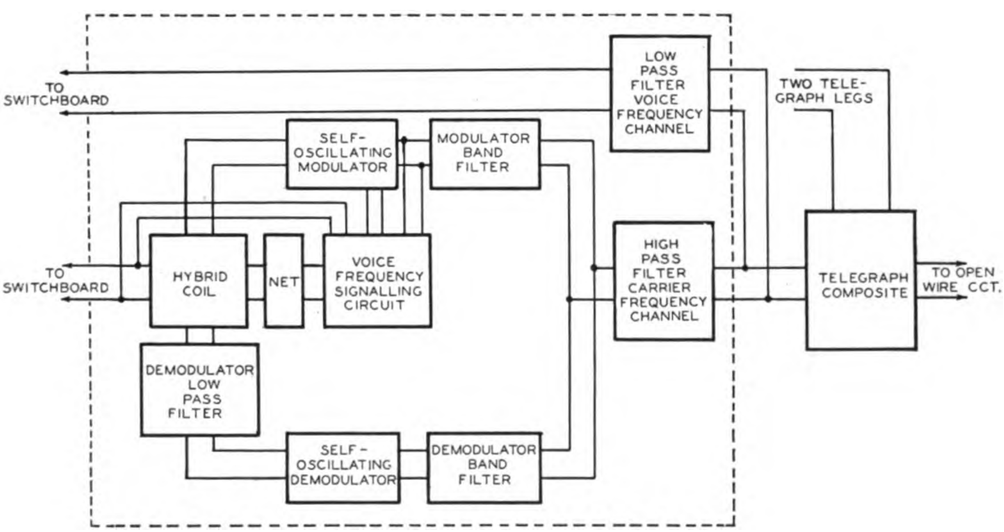


Fig. 1—Equipment symbolized inside the dotted lines is that for the D-1 System

be coordinated with other types of carrier systems present and future.

From the design standpoint these requirements called for the use of a minimum of apparatus, and the substitution of less expensive materials

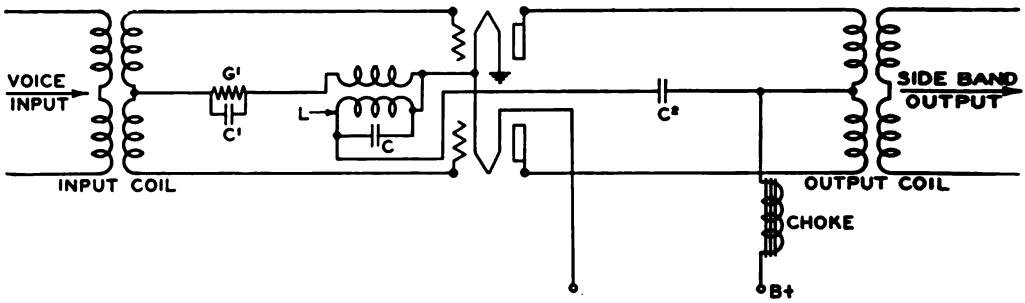


Fig. 2—Modulator circuit of the D-1 System

wherever possible. Ease of manufacture and control of product had to be considered. To reduce maintenance, few adjustments should be required and these should be made at the factory in order to simplify installation.

A system which met these requirements was developed and tested in the Laboratories. Following this work two models were placed at the disposal of the American Company for experimental studies and for tests of various transposition schemes on lines between Linden and Byram, New Jersey. Two more models were installed between Watertown and Syracuse, New York, for a commercial service trial. After successful completion of the service trial, manufacture and use of the system were approved for the more important applications throughout all parts of the the Bell System.

Technically, the Type D-1 single channel system is a self-oscillating, single sideband, two-carrier circuit employing only four vacuum tubes and a ballast lamp per terminal. The system as a whole is noteworthy because of the reduction which has been effected in the number of circuit elements. Among its new features are special methods of shielding, a new thousand-cycle relay, a new grid leak, and a new ballast lamp. Especially developed for the modulator and demodulator circuits are inexpensive paper condensers to replace the customary and more costly mica condensers, and inexpensive inductance coils not potted. These contributions, drawn from many groups of engineers, demonstrate anew how advances in the art are aided by the diversified skill to be found in the Laboratories.

Like all recent carrier systems, this one transmits in opposite directions on different frequencies. Westbound or southbound channels employ a carrier frequency of 10,300 cycles; transmission in the opposite direction employs 6867 cycles. These frequencies were selected for their bearing on transposition costs and to secure coordination with other types of carrier systems.

An ordinary two-wire telephone circuit is connected to each end of the system through a hybrid coil associated with a network to balance the impedance of this two wire circuit. Voice currents from the two-way telephone circuit are directed into the

outward carrier channel, while voice currents from the incoming carrier channel are directed into the two-way circuit in such a manner that neither interferes with the other.

The outward channel begins with a modulator — a device which displaces the voice band supplied to it, without alteration of its relative frequency intervals, to a higher position in the frequency spectrum. Instead of a group of frequencies in the voice range, we now have two groups — the two sidebands — one extending up, the other down, from the carrier-frequency as illustrated in Figure 4.

An outstanding feature of the Type D-1 system is found in its modulator which includes the carrier-frequency generator within itself. Complete scission of the two functions of oscillation and modulation is no longer considered necessary. The two tubes of Figure 2 working in parallel generate carrier oscillations whose frequency is controlled by the tuned circuit LC. The carrier-frequency output of the two tubes is coupled to the grid circuit and applies the same alternating voltage to each grid. This voltage is amplified by the tubes and the circuit oscillates stably in the customary manner. During a small portion of each positive half-cycle of the carrier wave, the grids are positive to the filaments as indicated by the black areas of Figure 3. During this period, electrons are drawn to the grids. From the grids they gradually flow back to the filament through the high resistance leak G', thereby establishing a steady negative grid bias (Figure 3).

With respect to the carrier oscillations, the tubes are in parallel but the primary windings of the output transformer are in opposition. Carrier oscillations, therefore, will not appear in the secondary of the transformer for transmission to the line. However, with respect to the voice-frequency band, the tubes and transformers form a push-pull circuit. The output of this circuit consists of three main parts — an amplified copy of the original voice currents, and two sidebands which are products of modulation. Only one of these sidebands — the lower one — is transmitted, all other frequencies being rejected by the output filter. This filter also rejects the sideband coming in from the distant terminal and diverts it into the demodulator circuit.

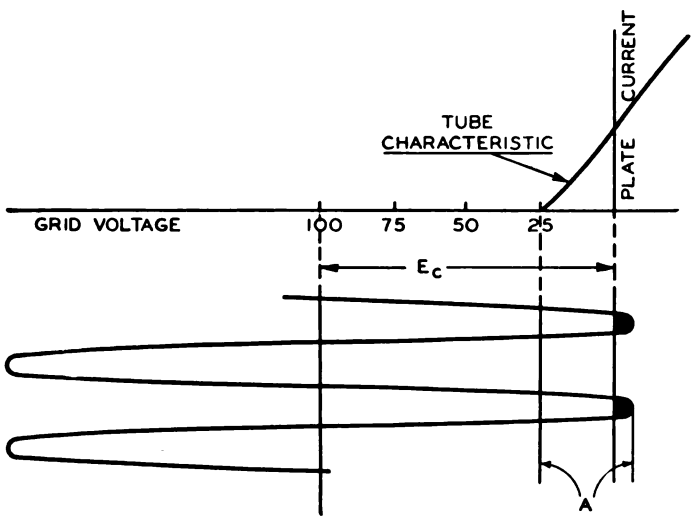


Fig. 3—Production of carrier-frequency oscillations by the oscillator-modulator tubes

Interposed between the terminal apparatus and the line is another filter which passes carrier currents in both



A single terminal equipment, mounted on a floor-type unit

directions but rejects the low frequency talking and signalling currents of the voice-frequency circuit on the same pair of wires. It is of great importance that these filters have the proper impedance to the currents which they are intended to pass, otherwise reflections will occur, and crosstalk with other systems on the same pole line will be seriously increased. Hence the design of these filters was one of the major problems in the development. Shielding was accomplished by sealing these filters in copper containers; thus interaction between adjacent filters was reduced to less than one part in a million.

At the receiving end, the sideband is transmitted without very great attenuation through the high-pass filter and demodulator band filter. The demodulator circuit is, in principle, a counterpart of the modulator circuit and oscillates at the same frequency. The sideband being impressed on the grids along with the local oscillations, there result in the output coil three principal groups of frequencies; an amplified copy of the sideband; a group of currents of still higher frequencies; and a group which is a duplicate of the original voice-frequency band. The first two groups are suppressed by the demodulator low-pass filter and only the voice-frequency band reaches the hybrid coil and ultimately the listener.

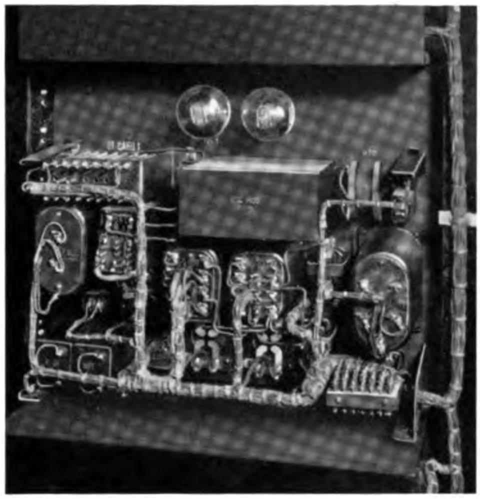
In the tuned circuit of the modulator are paper-insulated condensers having a number of taps. This permits adustment of the modulator frequency in steps of ten cycles. In the demodulator circuit an additional tapped condenser permits the oscillating frequency to be adjusted so as to agree with that of the distant modulator to within one cycle per second. The oscillating circuits are carefully adjusted at Hawthorne and are synchronized after the installation of the system.

Filaments of the modulating and demodulating tubes — four in all at each terminal — are connected in series with a retardation coil, a ballast

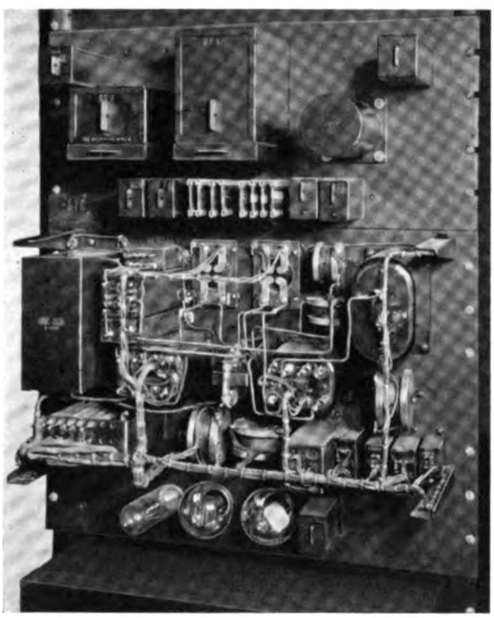
lamp, and the central office battery. Although the battery voltage may vary in the course of the day between twenty and twenty-eight volts, the ballast lamp holds the filament current variations within satisfactory limits.

The method of signalling corresponds, in general, to standard voice-frequency signalling methods in current use on toll circuits, with the exception that no thousand-cycle generator is required. Twenty-cycle ringing current from the toll switchboard is received by the signalling unit at the sending end, where it operates a relay chain. This relay chain serves to lower the frequency of the carrier oscillations by a thousand cycles and unbalances the modulator so that the carrier current may be freely transmitted to the line. Simultaneously the modulator output is short-circuited twenty times a second, so that the net result of an outgoing twenty-cycle signal is to transmit spurts of carrier current over the line. At the distant end the received carrier current differs by one thousand cycles from the local oscillations, so it appears in the demodulator output as thousand-cycle current interrupted at a twenty-cycle rate. This current after selection and amplification operates a thousand-cycle relay. If the rate of interruption of the 1000-cycle signal differs but little from twenty cycles, if the amplitude of the received signal exceeds a predetermined value, and if the signal endures for at least one-half second, then a chain of relays is operated and twenty-cycle ringing current from a local source is connected to the toll switchboard. These safeguards make the signalling system practically free from false operation on speech components but do not interfere with its reliability for signalling.

Supplementing the development in our Laboratories of the terminal



Reverse of lower panel, showing the modulator circuit



Upper panel carries signalling apparatus of the D-1 Carrier System; lower panel carries, on the side shown, the demodulator circuit

equipment, an economical scheme of transpositions has been designed by the engineers of the American Telephone and Telegraph Company which will permit the operation of a number of Type D-1 systems on the same pole lead and which is also expected to provide coordination with a limited number of Type C systems. One feature of this design is that it permits individual side circuits on an existing line to be retransposed as required for carrier operation with a minimum number of changes in the transpositions in other pairs not used for carrier operation.

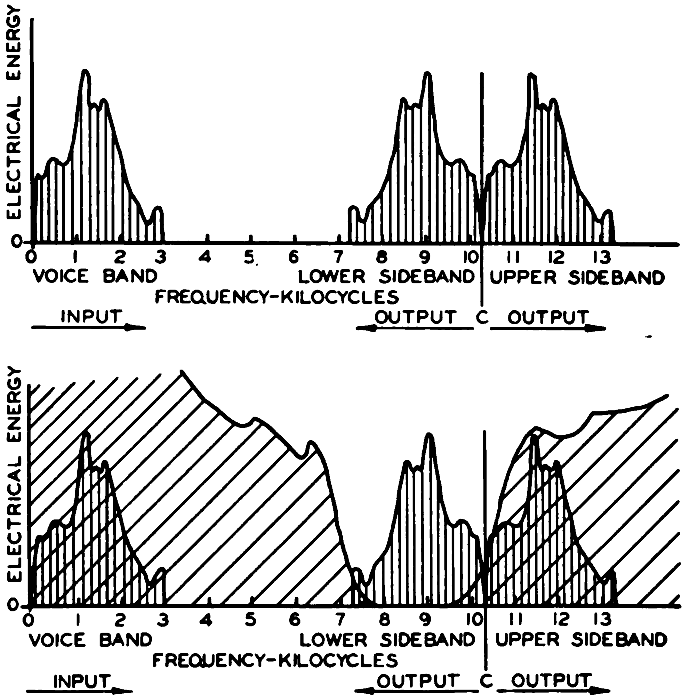


Fig. 4—Above, the location on the frequency spectrum of input and output currents of the modulator; below, how the band-pass filter eliminates all but the lower side band

Terminal equipment of the Type D-1 carrier system is furnished in two forms. One of these is for mounting two systems on a relay rack bay of standard height. The other, a self-contained floor type unit, is adapted to installation on short notice, and it is possible to cut a single system into commercial service a few hours after its arrival on the job. As an illustration of the utility of this general type of service, the discovery of oil in the vicinity of Amarillo and Borger, Texas, resulted in a sudden overload on the telephone facilities between those points. Using experimental parts mounted on circuit-boards, together with other equipment furnished by Hawthorne, the Laboratories assembled and cabled a complete Type D-1 system in the course of a few days. Ten days after the system had been shipped from New York it was cut into commercial service and fifteen calls were routed over it during the first half hour.

Determining Short-Wave Paths

By H. T. FRIIS
Research Department

SHORT waves do not travel so directly to their destination as the very long waves of the transatlantic telephone service do. The existence of skip distances* was discovered when short waves were first being experimented with but there still exists a lack of complete information on the actual path they follow in journeying between two points. Efforts have recently been made, however, to obtain some of the missing information by determining the direction in which the waves approach the receiving station. Complete information regarding the receiving angle will greatly help the computation of the actual path; it will add to the understanding of factors affecting short wave transmission; and it will give data of value in designing receiving antennae.

Two receiving antennae spaced a short distance apart will in general receive an incoming wave at slightly different times depending on the direction of reception. If the output of these receivers is each connected to a pair of deflection electrodes of a cathode ray oscillograph† the pattern traced on the face of the tube by the stream of electrons will be different for each direction of the incoming wave. In recent experiments a local oscillator was added to obtain a beat note of five hundred cycles with the incoming waves. This is necessary so that the signal may be amplified to operate the cathode ray oscillograph.

The method of determining the direction of reception may be readily understood by reference to Figure 1. The two receivers R_1 and R_2 are at right angles to the direction of the transmitter whereas the local oscillator is in line with it. If the signal

** In an article in* BELL LABORATORIES RECORD *for June, 1927, Vol. IV, pp. 349-354, J. C. Schelleng discusses this phenomenon at some length.*

† For a general description of the Western Electric 224-A Oscillograph used for the studies refer to BELL LABORATORIES RECORD *for April, 1926, Vol. 2, pp. 57-59.*

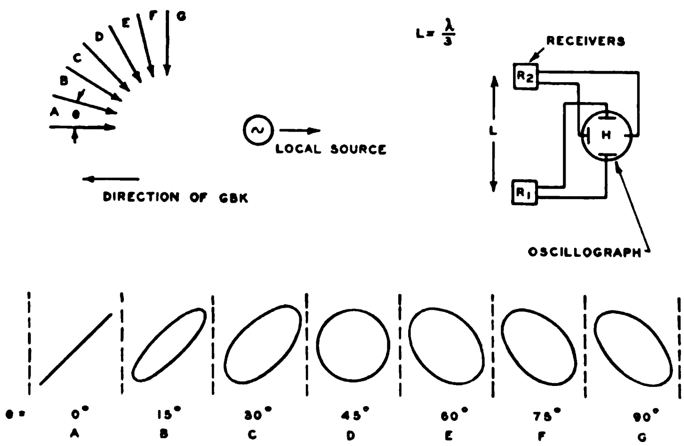


Fig. 1—Arrangement of receivers and local oscillators for determining horizontal-plane angle of reception

is received in the vertical plane passing through the transmitting station, the local oscillator, and the center of a line joining R_1 and R_2, there will be no phase difference between the received beat signal at R_1 and

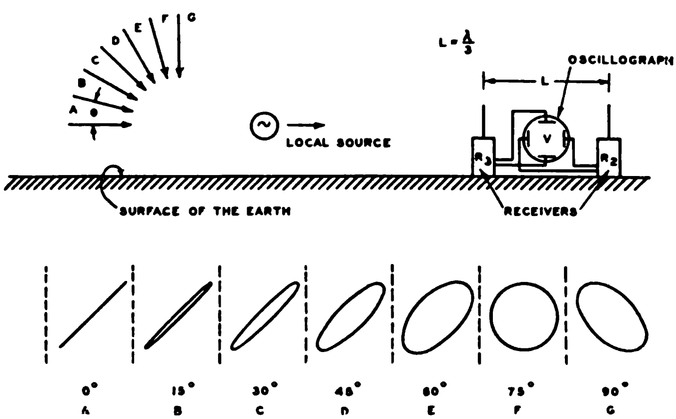


Fig. 2—Arrangement of apparatus for detecting vertical-plane angles

that at R_2, and the figure shown on the oscillograph will be a straight line as given at "A" in Figure 1. As the receiving angle increases through positions indicated as "B", "C", "D", etc., of Figure 1 the phase difference between the received signal at R_1 and R_2 increases and the figures on the oscillograph change as shown in Figure 1.

If, on the other hand, two receivers R_2 and R_3 are placed in line with the transmitter and the local oscillator as shown in Figure 2 a phase difference between them will also exist depending on the direction from which the received signal arrives. In the arrangement of receivers of Figure 1 only the horizontal plane component of the reception angle will produce a phase difference between the two receivers. In the arrangement of Figure 2, however, either a horizontal or vertical component of the angle of reception will produce a phase difference. If only angles in the horizontal plane are to be determined the set-up of Fig. 1 will give the data. To determine angles in a vertical plane both arrangements of receivers must be used together. Arrangement 2 is not sufficient in itself as this arrangement is responsive to a change of angle in either the vertical or horizontal plane.

By using arrangements 1 and 2 together, however, with receiver R_2 common to both, it is possible to determine both the horizontal and vertical components of the angle of reception. Extensive observations have been made using the British beam sta-

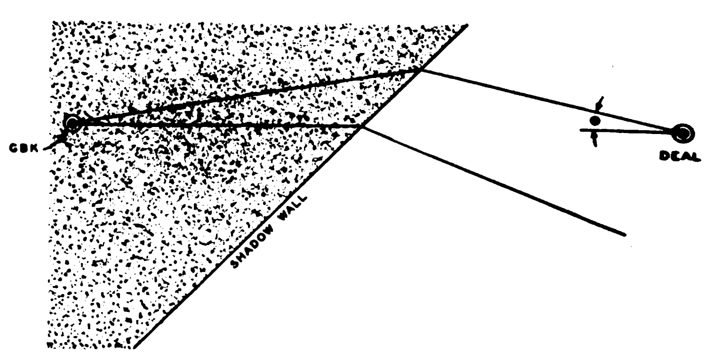


Fig. 3—Suggested way in which the shadow wall affects the receiving angle

tion GBK as the transmitter and much interesting data has been collected. It has been found that when daylight exists over the entire transmission path the horizontal angle of reception is small; the figure on the oscillograph is a straight line or a very thin ellipse. When the sunset or sunrise shadow-wall lies across the path of transmission, however, the angles increase at times to as much as thirty degrees, which seems to indicate a refraction of the short waves along the shadow wall.

The vertical plane component of the reception angles varies from time to time and occasionally reaches as high as sixty degrees. In the mornings the figures would indicate small angles. Towards noon they would change rapidly showing much variation in the height of the reflecting layer and this variation would continue on into the afternoon. Occasionally large angles were found in the mornings also which indicated an extreme variability. So variable is this vertical angle that any regular laws of variation of height could be determined only after a very long series of observations.

The possible significance of the horizontal component of the angle of reception is illustrated by Figure 3. The sunset shadow-wall is shown about half-way between the transmitting and receiving stations and the sketch shows how refraction along this line could account for the horizontal angles of reception noticed. To determine the actual laws of refraction at the shadow-wall, however, will require the collection of much additional data.

In watching the patterns traced by the two cathode ray oscillographs it was noticed that they changed not only from straight lines to ellipses but in size as well. As there was no change in strength of the local oscillator this could mean only a fading of the received signal. In many cases there seemed to be a cycle from large to small figures taking from one to

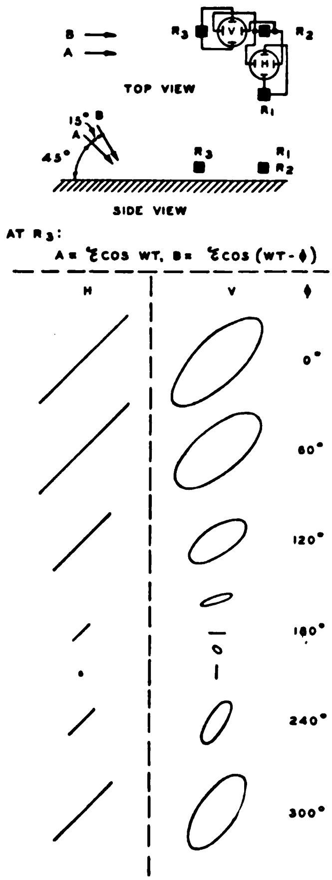


Fig. 4—Illustration of fading effects due to reception of two waves at slightly different angles

five seconds. The small figures seemed at first very irregular in shape but careful observation proved that usually they consisted of a small line or ellipse rotating rapidly one way or the other.

These rotating figures and the constant change in the direction of reception suggest that fading is caused by

changing wave interference. Two waves travelling by slightly different and constantly changing paths would suffer continually changing interference and produce a changing series of figures on the oscillograph. Figure 4 shows such a series of calculated figures for two equal waves arriving at the angles given at the top. These calculated figures bear a striking resemblance to the actual figures observed at times on signals from G B K. The signal figures are sometimes much more complicated but this may be caused by interference between more than two waves, or between two waves of different amplitude. Although fading of short waves may be caused also by rapid changes in absorption it is believed that changes in wave interference are by far the commonest cause of this phenomenon.

The Terms of Settlement

Whenever the purpose of life insurance is to supply protection for dependents, the stipulations by the insured as to the terms of payment to the beneficiary are of paramount importance. Failure on the part of the insured to specify some plan of payment means the sudden placing of a large sum of money in the hands of the beneficiary for investment. It all too often happens that a widow and her insurance money are soon parted. One of the attractive features about the employees' insurance plan recently adopted by our Laboratories is that it stations in our midst an insurance expert whom we may consult in regard to such important matters as terms of settlement. This applies to those whose insurance antedates the plan as well as those who are coming in under it. So many plans are available that almost any combination of events may be intelligently anticipated. Neglect is inexcusable, since it means the throwing of heavy responsibilities on survivors when they are least able to bear it.

A New Non-Multiple P.B.X.

By V. I. CRUSER
Systems Development Department

WHEN the need for private branch exchange service first originated most of the Telephone Companies designed their own equipment and, as a result, a large number of different types were manufactured with an inevitably large manufacturing cost for each. However, in 1904 a non-multiple switchboard designed to meet the common needs of all the Associated Telephone Companies was developed and manufactured. This switchboard was known as the No. 4 P.B.X. Since that time many changes in the design of both the framework and circuits have been made in order to keep this part of telephone equipment abreast of the other branches as the art of communication progressed.

The demand for private branch exchange service grew rapidly and in 1916 the 550 type non-multiple P. B.X. was designed, with a framework improved both in appearance and construction, to replace the No. 4. The 550-A and 550-B boards were developed in rapid succession. This type was made in three different sizes: one with a capacity for thirty station lines, another for eighty lines, and a third for 320 lines. In 1920 the design was modified to add dialing equipment so that the boards might work into dial central offices and the board was then called the 550-C.

The 551 type P.B.X. switchboard, which replaces the 550-C, is a product of 1927. In the early part of that year the basic ideas for the new design began to crystallize. The design was completed, the manufacturing plans laid, and the production tools made up before November, when production of the new boards began. Before the end of the year the first lot was shipped and placed in service.

The 551 type P.B.X. was designed to improve maintenance conditions as well as to reduce the cost of manufacture. The same operating features are employed in the new board as



Fig. 1—Front view of 551-A P.B.X. without transmitter

were used in the 550-C. However, in place of the three different 550-C framework sizes, that is the thirty, eighty, and 320 line boards, the 551 type P.B.X. is made in only two sizes but arranged for three capacities: the smaller size with a capacity for forty station lines, known as the 551-A; and the larger, with a capacity for 320 lines, known as the 551-B. The large board may be equipped for a maximum of either eighty or 320 lines. The capacity of the thirty line board was increased to forty lines in order to increase the demand for the 551-A board by absorbing a part of the demand for the discontinued eighty line size.

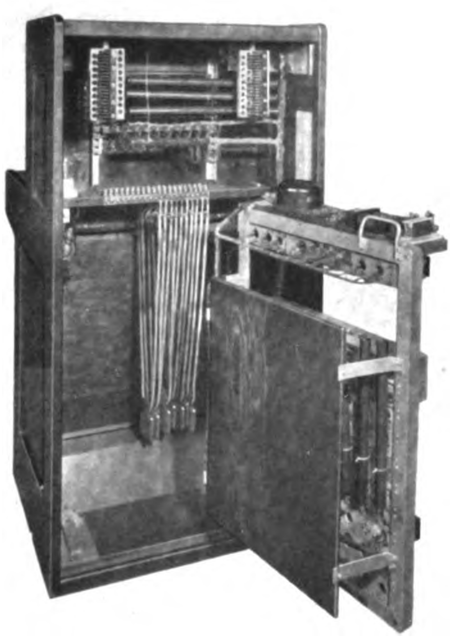


Fig. 2—Rear view of 551-A with relay gate open showing the cord-weight protection panel in place

In the new board strip-mounted jacks and lamps are used for the station lines. All apparatus inside the section, except the hand generator and ringing resistance lamp, is mounted upon a relay gate which makes the equipment immediately available for adjustment while the gate is closed and leaves the wiring fully exposed when the gate is open. The cord-weight protection panel is mounted on the relay gate rather than being fixed in the section so that when the gate is open and work is being done on the cords or hand generator the gate wiring is still protected from damage.

As the new type of P.B.X. was developed, features were incorporated in it so that it could be manufactured on a progressive assembly basis in line with the general tendency for mass production. An assembly plan has been worked out in conjunction with the engineers of the Western Electric Company so that the interval of manufacture for the 551 is ap-

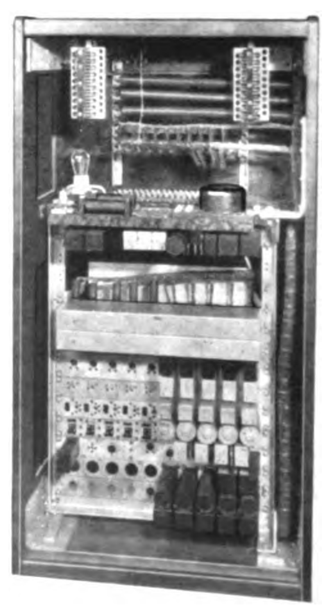


Fig. 3—Rear view of 551-A with gate closed showing relays mounted on outer side

preciably less than that of its predecessor. In place of carrying on the different phases of manufacture in various departments throughout the manufacturing plant, the new boards are completely assembled, wired, tested, inspected, and even crated in one department. All of these operations are concentrated in one shop and are so timed that one follows on the heels of another, in proper order in the progressive assembly line.

The framework for the new switchboard is made up of a minimum number of parts. Essentially it is formed of a floor, a roof, and two end panels of wood assembled together by means of large bent angles of sheet steel screwed in the four corners. To this are added the keyshelf, front panels, and rear door to complete the housing for the equipment. The rear equipment in both the 551-A and the 551-B is mounted upon the welded angle-iron gate. This gate is so placed in the framework that it not only serves to mount the equipment in a position easy for maintenance but, when locked in a closed position, reinforces the framework.

One of the chief objects of the new design was to eliminate as far as possible the repair work on the woodwork required after the boards are placed in service. After studying conditions at various branch houses it was found that the keyshelf and face of a P.B.X. were the first to become worn and that repairs on these parts made up the larger part of all framework repairs. To avoid this and to give the new boards a longer field life, both the keyshelves and the fronts of the 551 P.B.X.'s have been faced with phenol fibre rubbed a dull

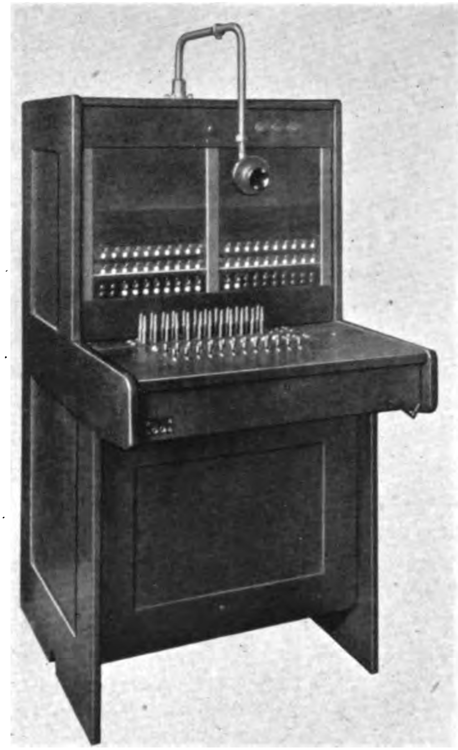


Fig. 4—Front view of 551-B P.B.X. equipped with standard transmitter

black which not only results in a pleasing rich appearance but provides a very hard and durable surface.

As is so often the case, the development of this new P.B.X. has resulted in a board easier and cheaper to manufacture as well as one that is more pleasing in appearance and that is easier to maintain in the field than the board it replaces.

Some Early Cable Terminals

By A. F. GILSON
Assistant Apparatus Development Engineer

AMONG the many problems arising from the use of lead covered cables is that of providing a suitable termination. The conductors of ordinary lead covered telephone cable are insulated with unimpregnated paper which is a very effective insulator when dry but a very poor one when wet. Measures must be taken, therefore, to prevent moisture from reaching the paper, and the lead sheath does this very effectively. At the ends of the cable, however, where the lead sheath ends and the conductors are connected to line or distribution wires, or to other cables where a sheath splice cannot be made, moisture could readily enter and impair the insulation if special steps were not taken to prevent it. Cable terminals are the devices used for this purpose and many types have been developed to meet a large variety of requirements.

The first solution of the terminal problem was direct and simple. A lead sleeve somewhat larger than the sheath of the cable and perhaps fifteen inches long was slipped over the end of the cable and slid back a few feet to be temporarily out of the way. The cable sheath was then cut back a short distance, the wires spread out, and paired rubber-covered wires were spliced on to them. Following this the loose sleeve was moved back till it covered the splices and the cable end of it was formed around the sheath and a straight wiped joint was made to prevent the entrance of moisture. The sleeve was then filled with a sealing compound which after cooling was covered with a layer of asphalt compound as a further seal against the entrance of moisture at the open end. In con-

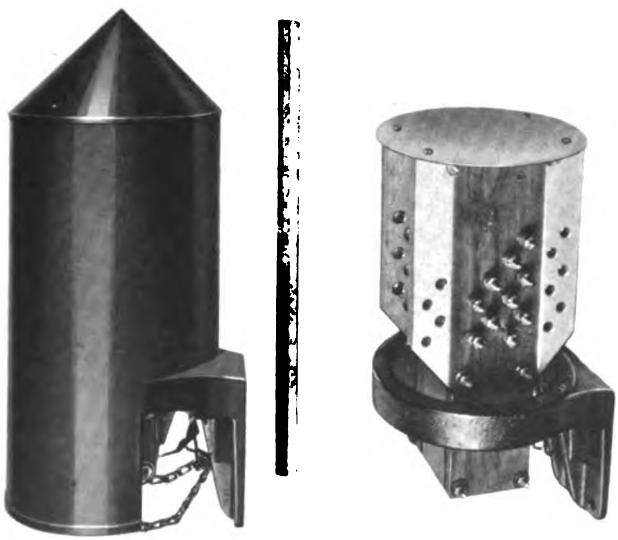


Fig. 1—Early 8-A cable terminal with protecting cover in place on the left, and with cover removed on the right

nection with the pothead the Telephone Companies used various types of boxes equipped with connecting blocks or fuse mountings to which the wires from the pothead were con-



Fig. 2—Diagrammatic sketch showing method of forming pothead

nected. The drop wires were then run from these connections to the subscriber's stations.

The pothead, as it was called, accomplished its purpose of protecting the interior of the cable from moisture and did it very simply. It has certain obvious failings, however, which another early type, called sealed chambers, attempted to avoid. These were iron chambers mounted in wooden boxes, the former being provided at the bottom with brass nipples through which the cable entered and to which its sheath was soldered to exclude moisture. Through the side walls of the chamber extended insulated binding posts and the conductors of the cable were fastened to their inner ends. After all the connections were made the chamber was usually filled with a sealing compound. From the projections of the binding posts on the outside of these chambers connections were taken for the subscribers' stations. By this means, therefore, the cable was not only satisfactorily sealed but points

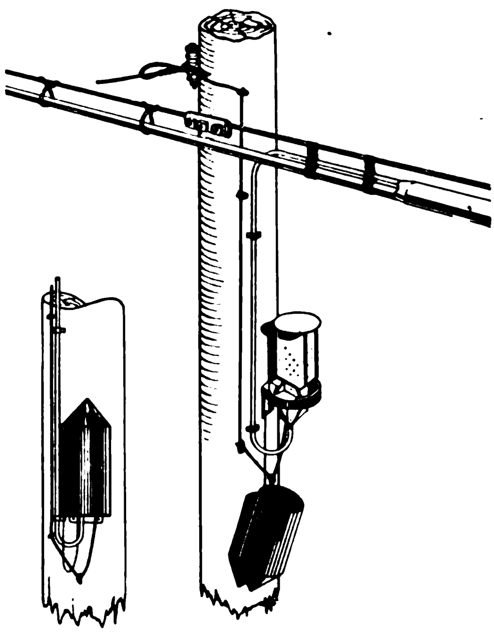


Fig. 3—Method of mounting No. 8 type terminal on telephone pole

of attachment were provided for the connecting wires.

Use of the potheads and sealed chambers resulted in a wide assortment of cable terminals, as many different arrangements were used to meet the various requirements of the

Associated Companies. To better this situation by providing a standard means to connect open wire to cabled telephone circuits the development of standard terminals was undertaken,

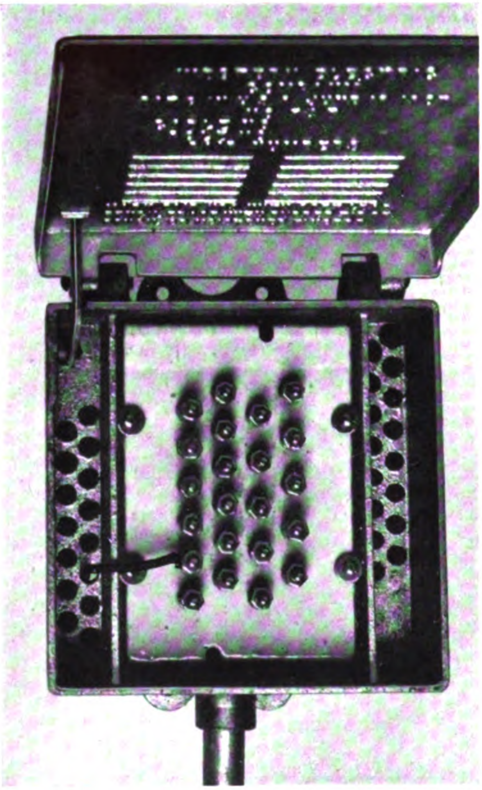


Fig. 4—No. 14 type cable terminal with porcelain block in place

leading to the various types now used.

In all the later development the sealed chamber principle was used. The cable entered a chamber of one form or another, its sheath was soldered or otherwise sealed at the entering point, its wires fastened to binding posts running through the sides, and finally the chamber filled with a compound to complete the sealing of the cable. In addition, an outer covering, usually consisting of a wooden box or metal cover, was provided to protect the terminal and its connections from direct exposure to the weather. The many forms of terminals subsequently developed were necessary because of different sizes of cable to be accommodated and because of the different classes and conditions of service.

The first two types designed, the No. 8 and the No. 14, were both primarily for connecting local cables to subscribers. The No. 8 had for its sealing chamber a rectangular wooden box about a foot long and a few inches in width and breadth. The cable entered through one end and at this place its sheath was wrapped with adhesive tape and held between wooden clamps which closed that end of the box. Through two of the opposite sides of the box projected the required number of binding posts to terminate all the wires in the cable. A six-and-a-half-foot length of 22-gauge cable was built into the box at the factory.

In assembly, the wires of the cable stub were all soldered to the inner ends of the binding posts. After this the box was bolted together, the clamp on the sheath adjusted at the lower end, and then the whole filled with sealing compound from the top, which was afterward covered over with a circular piece of sheet metal.

The wood composing the two sides containing the binding posts was cut a few inches wider than the box over the upper two-thirds of its length. These projecting flanges were drilled opposite each binding post to serve as fanning strips which allowed the entering wires to be run to their proper terminals.

The entire box was supported by a cast iron bracket as shown in Figure 1. The vertical part of this bracket was made for fastening to poles, and

the annular part supported a cylindrical can, which covered the entire terminal in service, and allowed space for the entering wires to pass through it to the fanning strips. The can was chained to the supporting bracket so that it would not be dropped from the pole or lost. This No. 8 type terminal was made in 10, 16, 26, 31, and 51 pair sizes, but the two larger ones were rarely used.

The No. 14 type* reverted to the earlier forms of terminals in using a cast iron sealing chamber. It is very satisfactory for mounting on the sides of buildings or other flat surfaces as well as on poles, and is usually mounted so that the hinged cover will be closed by gravity. The movable arm shown in the accompanying photograph is used to support the cover while connections are being made.

The terminal block through which the binding posts pass is of porcelain and covers the front of the sealing chamber proper. The rear of the porcelain block has a ridge formed on all four sides which fits into a corresponding depression at the sides of the sealing chamber. The ridge is drawn into the groove against packing material to make the whole perfectly tight. This box also is assembled at the factory with a cable stub similar to that of the No. 8, which may be made other than the standard length on order.

Provision is made for the cable to enter at either the top or bottom of the box as may be specified. The end not used for the cable entrance is used to fill the sealing chamber after the cable conductors have been soldered to the binding posts and the terminal block fastened into place. This second opening is then closed with a pipe plug. To protect the cable from too sharp a bend and to provide a tight joint, a combination of brass and lead nipples are used at the entrance point.

The sealing chamber is deeper than the rest of the box and on its rear side carries the lugs at top and bottom which are used for fastening the box to the building or other support. In the back surface of the box proper,

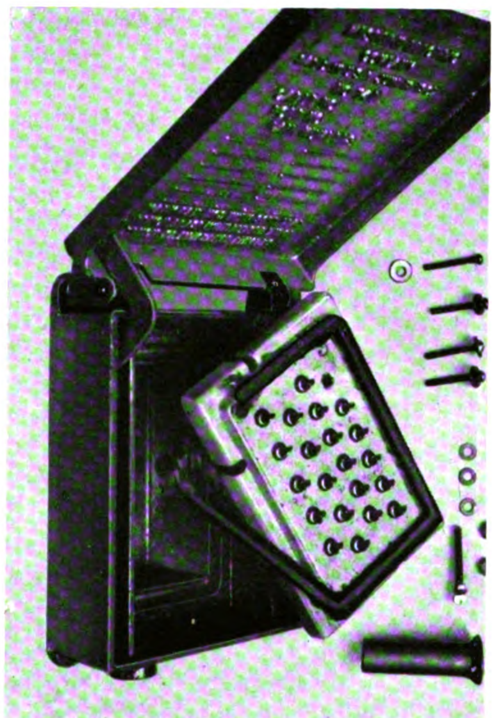


Fig. 5—No. 14 type terminal showing construction details

between the sealing chamber and the two outer sides, are holes which enable these two narrow sections to serve as fanning strips. Incoming wires thus enter from the back of these two shallow wings and are fan-

* *This terminal was originally designed by S. P. Grace, now Assistant Vice-President of Bell Telephone Laboratories but at that time Chief Engineer of the Central District and Printing Telegraph Company, and R. A. L. Snyder, his associate, who continues in the successor organization, The Bell Telephone Company of Pennsylvania.*

ned out to their proper binding posts. The No. 14 type terminal is made in 11, 16 and 26 pair sizes only.

Of the No. 14 type terminal, the Western Electric Company has made to date about two and a half million. It is the only terminal so far described that is still standard with the Bell System. The potheads and earlier boxes went out of use because the No. 8 and No. 14 were less expensive to maintain. The No. 8 has gone out of use only recently because greater experience with terminals has made it possible to design types which have higher insulation resistance and are easier to install and maintain. The terminals to be described in a later article are designed on the basis of many years experience and are in many forms to meet the increasingly complex conditions found in the field.

A Newspaper Comment From France

La Nature du premier janvier nous apprend que le recensement entrepris par l'Academie des Sciences de Washington, en excluant les laboratoires officiels et les petits laboratoires privés, relève mille laboratoires au service des grandes industries. . . . La Societé Bell, à New York, pour ses recherches de télégraphie et de téléphonie, emploie plus de deux mille techniciens, formés par les plus grands savants des plus florissantes universités et disposant de laboratoires de recherche et d'experimentation. Et nous concluons, avec notre confrère, que l'hégémonie industrielle américaine n'est pas due seulement à des avantages naturels exceptionnels, mais aussi — probablement surtout — à l'esprit de travail, de méthode et d'organisation.

— *L'Ouest (Angers)* 15 *janvier*, 1928.

Very Thin Films of Rubidium

By A. L. JOHNSRUD
Research Department

SOME of the recent developments in the art of communication, such as telephotography, talking motion-pictures, and television, have as an essential part a photoelectric cell whose function is to yield an electric current faithfully proportioned to the amount of light falling upon it. For the cell to yield this current most efficiently and in amounts large enough for practical use, a long process of development has been necessary. This in turn has been based on extensive research on fundamental problems in photoelectricity, carried on in our laboratories under the direction of H. E. Ives.

Long preceding the recent concerted efforts in bringing photoelectric cells to a high state of development, it had been noticed that alkali metals were more efficient in yielding photoelectric currents when in thin films than when in bulk. It was therefore desired to know more about the relation between film thickness and photoelectric response.

The commonly used alkali metals include sodium, potassium, rubidium and caesium, all more or less photoelectrically sensitive. Rubidium lends itself best to the study of thin films. It volatilizes, diffuses and deposits in vacuo at temperatures in a range conveniently near room temperature, and in short time-intervals suitable for experimental purposes.

For the most effective study of the phenomena involved, there was constructed a large vacuum cell containing enough rubidium to allow a spontaneous deposit to take place on all internal surfaces until equilibrium at room temperatures had been reached. This deposit, so thin that it was quite invisible, covered not only the walls but a thin square piece of glass in the interior as well. Supporting this plate at opposite ends were platinum wires, sealed onto the front surface to make contact with the metal film. A tungsten filament, supported close behind the plate, provided radiant heat for driving off the rubidium whenever desired. The photoelectric current was collected on a large nickel anode which nearly enclosed the glass plate and filament, and an area of the cell wall was kept clean with a flame to provide a window for light to pass through to the plate.

It was found, as expected, that a heavy coating of rubidium, actually constituting a solid metallic surface, gave considerably smaller photoelectric currents than those obtained from thinner films. It was likewise noted that films which had not had time to deposit to their equilibrium thickness gave smaller photoelectric currents than those that had come to equilibrium. Two series of measurements of photoelectric current were therefore required—one while the thickness was diminishing from that of the heavy opaque coating to the equili-

brium value, and the other while the rubidium was depositing on the freshly-cleaned glass plate. During each process the electrical conductivity along the surface of the glass plate was being measured. This approached the same value, regardless of the direction from which the equilibrium point was approached. The question then became "How thick is the film at its equilibrium value?"



Mr. Johnsrud operates the polariscope, by which the thickness of very thin rubidium films was measured

It might be possible to calculate the thickness of the film from its lateral dimensions and its specific resistance. But was the assumption justified that such a thin layer of metal would conduct electricity in exactly the same manner as would a considerable volume of it? True, it obeyed Ohm's law in the dark, but its resistance might in some way be altered under illumination. This was especially probable since the thickness of the film was comparable to the diameter of the rubidium atoms themselves. Measurement of thickness by means of resistance was therefore considered unreliable in this particular case.

Here is where a new method of measurement had to be adopted, surpassing in fineness not only microscopes of the highest power, but interferometers as well. The measurement must reach the formerly inaccessible region between visible light and X-rays, radiations whose wave-lengths bear to each other roughly the ratio of ten thousand to one.

It seemed likely that the thickness of the film to be measured would be as little as one atomic diameter, one half of one millionth of a millimeter. Waves of light convenient to work with are a thousand times as great as that in length. It was decided, therefore, to base the measurements of thickness on the principle that plane-polarized light, in passing through any film, experiences a rotation of its plane of polarization. The extent of the rotation is governed by the thickness of the film, the wave-length of the light and the angle of incidence. By using light of a single wave length (the green line of the mercury arc spectrum), and taking a set of observations at different angles of incidence with a polarization spectrometer, we were able to obtain accurate values of the thickness of the rubidium film from the known constants of the material.* This was possible not only at the

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* *The difficult task of preparing the many sets of calculations required was performed by T. C. Fry and his associates.*

equilibrium, but while the film was growing or diminishing. By interspersing optical and electrical measurements, we were able to measure the rate at which the film increased or diminished in thickness.

The following results were noted:

1. At room temperature, the thickness of the spontaneously deposited rubidium film was approximately one atomic diameter.
2. The depth of penetration of light into solid rubidium as measured by the means and in accordance with the theory described in the text was found to be as great as twenty atomic diameters.
3. In spite of this penetration of the light, the photoelectric current emitted from solid rubidium was approximately the same as that derived from a film one atomic diameter thick.
4. A film of rubidium so thin as to yield a thickness measurement of less than one atomic diameter is electrically conducting. Since the underlying glass surface under those conditions must be only sparsely covered with atoms, it appears likely that the metal atoms are in rapid motion over the surface, and that conduction is made possible by their collisions.

Instructors Entertained at Luncheon

MARKING the completion of the ninth consecutive year of the Out-of-Hour Courses those members of the technical staff who were instructors in last season's courses were entertained at lunch on May 29 by Mr. Craft.

Following the luncheon Mr. Craft, as host and toastmaster, recounted the philosophy of the Out-of-Hour Courses. He pointed out that in carrying on the work of the Laboratories consideration must be given not only to doing well to-day's job but to developing an organization to carry on to-morrow's work even more effectively. The Personnel Department was organized ten years ago as a help to this end. Studies during the first year brought out that there was a general feeling of need for some means to make available information on our work. The organization had been growing rapidly so that there were many new members who felt their limitations as compared with the seasoned veterans who had gathered their information and background through years of experience. To take care of this need some of the departments were carrying on conferences within their own organizations and a number of groups of individuals were getting together out-of-hours to exchange information or have an expert give them the benefit of his experience.

A study of the whole situation indicated that the newer members of the organization could be broken in more rapidly if means were provided whereby the information on subjects of vital interest to the Laboratories could be collected, arranged, clarified and explained so that any member of the organization might have access to

the principles and practices which the experts had developed and worked out during the past years. It was felt that this information would be more effectively disseminated if classes were held. This would give the stimulation which comes from definite scheduling and from group discussion which brings out more ideas than does individual study. It was also felt that these classes should be on an opportunity basis where any member of the organization who had the proper qualifications might be enrolled in a course. It developed on consideration that the only time which would make this practicable would be outside of regular business hours.

A study of educational plans of other industries showed that much had been done. The Hawthorne Club had conducted a good many classes in which club members were enrolled. These classes were conducted as a club and not as a Western Electric activity. Other organizations were preparing for similar activities and a study of these and other plans all had the common characteristic that they were organized as separate from the business. After careful consideration it was deemed wise to set up the educational plans for out-of-hour courses in the Laboratories on the basis that they were a regular part of our work, recognizing that through these courses the Company was making available for present and future members of the organization information on past accomplishments.

Our own experience indicates that this method of considering educational work a part of the regular business gives satisfactory results. Further evidence of soundness of this plan is shown by the fact that the Western Electric Company in New York City and the New York Telephone Company recently started out-of-hour courses fashioned after those conducted in the Laboratories.

To carry out this plan the instructors must be those who are recognized experts in their respective fields. As a consequence, instructors have not been self-selected nor are they selected by any individual or a fixed group of individuals. Each is naturally selected as the one who is recognized by his associates as being the most capable and available person. As the preparation of text material requires additional work on the part of the instructor, he is not assigned to this work by his department but is invited to conduct a class.

Reviewing the accomplishments of the past nine years, M. B. Long, Educational Director, said that eighty per cent of the present Technical Staff had taken part in one or more of the courses. A total of seventy-two different courses have been given —some of them repeated several times —by 147 members of our organization as instructors. A total of 3,149 individuals have taken one or more courses; this year there were 592 enrollments.

During the year just ended twenty courses were given. One course, Theory of Telephone Transmission, has been offered each year although revised several times. The period during which any one individual has acted as instructor ranges from a minimum of one-half to a maximum of six years. During the past year twenty-eight instructors contributed to the carrying on of the plan.

In keeping account of the total load brought about through the giving of the course some basic unit of measure seems to be desirable. The

student class hour has been selected as that unit and a study of the past years shows an average per year of 13,000. During the past year, 1927-1928, the total load was about 16,000 or about 30% above the average. If we are interested in the total load placed upon the members in this regard we must take into account the outside time required for preparation. It seems, therefore, that 50,000 person hours is a reasonable figure to express as being given to out-of-hour courses during the past year.

During each of the last few years sixteen of the courses have had a capacity demand and so have come to be looked upon as fundamental to the plan. They have therefore been repeated a good many times and now play such an important part in the training of new men that the text materials have been worked over and revised until in some cases they seem to have become almost an official encyclopedia. In concluding, Mr. Long expressed considerable pleasure in having the opportunity to extend his appreciation to those who this last year had acted as instructors, for their all important part which made the courses possible.

For the instructors, Timothy E. Shea discussed their efforts and their future. As a result of personal contact made in out-of-hour courses many a conference has come off more smoothly and many a memorandum has been improved. There is also opportunity for the intrinsic development of the instructor himself, through the discipline exacted by the organizing of course material and the capacity developed for sustained effort, the opportunity for self-expression in class room and in text, an increase in self-confidence which is reflected in his daily work, a widening of his mental horizon and an opportunity of studying his students. The students are also studying their instructor, and so there is opportunity for the building of professional reputation. Decidedly, the instructor profits from the time and energy put into preparing and presenting his course.

Since many of the courses cover subjects which are not suitably treated in existing books, new texts have to be evolved by the instructors. How these texts are made available for newcomers in the Laboratories, and subsequently to wider audiences, was discussed by John Mills, Director of Publication. Four books by members of the Laboratories have now been published, and several others are in preparation for publication.

Saying that the occasion would not be complete without a few words from "The Dean," Mr. Craft called upon George B. Thomas, Personnel Director. Mr. Thomas congratulated the instructors on the splendid results in their year's work, praising particularly their excellent spirit of cooperation.

Mr. Craft concluded the program with remarks on the coordinating influences of the courses. He expressed his feeling that the soundness of the plan was thoroughly evident and that the effort was thoroughly justified. He extended his thanks to the instructors for their loyal part in a job well done and predicted that the same spirit would carry us forward through the work of tomorrow.

News Notes

THE degree of Doctor of Engineering has been conferred upon F. B. Jewett by the Case School of Applied Science in Cleveland. In conferring the degree, President Charles S. Howe referred to Dr. Jewett as "a profound student of electrical engineering; skillful investigator of many engineering problems of electricity; effective and inspiring teacher of engineering, and wise and efficient administrator of a great research laboratory." Dr. Jewett also delivered the Commencement Address at Case School, the title being "The Problems and Prospects of the Young Engineer—How They Differ from Those of His Father."

On June 9, President John M. Thomas of Rutgers University awarded President Jewett the honorary degree of Doctor of Science.

ON MAY 14 Mr. Jewett attended a hearing of the Federal Radio Commission held in Washington on allocation of short waves. Other recent activities of Mr. Jewett include attendance at a Past Presidents' luncheon of the A.I.E.E. on May 22, and a dinner of the Society of Arts and Sciences, at which a gold medal was conferred on Thomas A. Edison. Mr. Jewett, representing the engineering societies, spoke on "Edison as Seen by His Fellow Engineers."

Mr. Jewett is a member of the American Committee of the World Engineering Congress that is to be held in Tokio, Japan, in October, 1929. He was recently appointed Chairman of the subcommittee on transportation.

AT THE REGULAR WEEKLY MEETINGS of the Vice-Presidents of the Western Electric Company on June 6 and 13, E. B. Craft spoke on the cost-reduction work of the Bell Telephone Laboratories during the past year. On June 15 he addressed the members of the Department of Development and Research on the internal operation of the Laboratories. In May he addressed the members of the Bell System Operating Conference held at Absecon, New Jersey, on activities of the Laboratories.

DR. CRAFT was the speaker at the Commencement Exercises of Worcester Polytechnic Institute on June 18. His subject was "Industrial Research." Later he addressed a group of men at the Worcester Club, guests of Mr. Charles M. Thayer, on research and development in the communication industry.

PROFESSOR W. F. G. SWANN of the Bartol Research Foundation addressed the Colloquium on May 28. Speaking on the topic "Possible Modifications in Electrodynamics and Their Consequences," he explained the earth's charge and its magnetic field by assumption of a slow destruction of positive charges.

J. C. HUNSAKER spoke at the dedication of the Daniel Guggenheim Aeronautical Laboratory at Massachusetts Institute of Technology on June 4, outlining the history of the Department of Aeronautics, which



Graduates and instructors of the General Health Course: back row: the Misses Heiart, Menig, Cassidy, Fitzsimmons, Spindler, Beers, Mihavetz, Prouty; seated: the Misses Dunbrack, Murison, Sall, Crawford, Van Riper, Egan, Bauer. Other graduates, not in the picture, are the Misses Gregory, Paret, Rossi and Tully

was established in 1914 with Mr. Hunsaker as an instructor.

MR. HUNSAKER has been appointed to the technical committee of Trans-Continental Air Transport, Inc.

GRADUATES of the first two classes in the General Health Course for Women in the Laboratories attended on May 28 a tea held at the Fifth Avenue Hotel in honor of the graduates of the third class, which began October 4, 1927. This class, like the preceding ones, was taught by Statira Crawford of the Medical Department, assisted by Gratia Prouty of the Employee Service Department. Seventeen girls out of the twenty-nine registered finished the course. The certificates were distributed after the tea by George B. Thomas, Personnel Director.

A VISIT TO THESE LABORATORIES on June 11 was part of the program of the Ninth International Cost Conference, held in this city under the auspices of the National Association of Cost Accountants.

APPARATUS DEVELOPMENT

J. J. LYNG, O. M. GLUNT AND E. L. NELSON visited Hadley Airport near New Brunswick, New Jersey, on June 8 to inspect the radio laboratory facilities that have been provided at that point and to witness the initial test flight undertaken by the radio development group. The Laboratories' Fairchild plane, piloted by A. R. Brooks, was equipped with a field strength measuring set and was taken up for a fifty minute flight during which observations on the strength of the signals from 3XN were made by P. H. Evans and E. F. Brooke.

D. H. NEWMAN visited Roanoke, Virginia, late in May to make the survey for the Richmond Development Corporation's one-kilowatt broadcasting station. Later he visited Chicago, where he installed the five-kilowatt transmitter of the Chicago Daily News.

H. S. PRICE recently inspected WEEI, the station of the Edison Electric Illuminating Company of Boston.

W. L. TIERNEY made the survey for the five-kilowatt installation purchased by the Western Broadasting Company to replace their 500-watt equipment at Station KNX.

C. H. GREENALL AND A. H. FALK visited the laboratories of the National Lead Company in Brooklyn on May 18 in connection with proposed tests for the lead case for submarine loading coils. C. R. Young joined them in a trip through the two National Lead plants at Perth Amboy on May 22.

J. R. TOWNSEND attended a meeting of the A. S. M. E. committee on spring design in Pittsburgh on May 16, and was appointed chairman of a subcommittee on spring materials.

H. A. ANDERSON spent some time with the Ingersoll Rand Company in Phillipsburg, New Jersey in connection with the heat treatment of climbers to eliminate the possibilities of failures from brittleness.

A. D. HARGAN visited several Boston exchanges on June 1 in connection with multiple bank problems.

H. F. DOBBIN AND W. GOFF visited the plants of Brown & Sharpe at Providence, and Pratt & Whitney at Hartford, Connecticut, on May 22 and 23, to investigate the latest methods of cutting and grinding gears.

ON JUNE 14 the Specification group tendered to H. W. Heimbach a luncheon at a nearby restaurant to mark the occasion of his transfer to the staff of W. T. Booth, Executive Assistant. Mr. Heimbach has headed the Specification group since its inception in 1919. A testimonial scroll, signed by every member of his own group, was presented with a wrist watch as concrete evidence of personal regard. Voicing the same sentiments, members of the Apparatus Files group gave Mr. Heimbach a pen and pencil set, and decorated the luncheon tables with flowers.

BASED ON THEIR EXPERIENCE IN THE LABORATORIES, the degree of Electrical Engineer has been conferred by Cooper Union on J. B. Shiel, W. J. Turney and H. L. Walter, graduates in former years of the evening courses of that institution.

GENERAL STAFF

S. P. GRACE was the guest of honor at a dinner given by Mr. C. W. Bergquist at the Union League Club of Chicago, prior to a lecture by Mr. Grace before the Western Society of Engineers.

MR. GRACE spoke before the executive and supervisory staffs of the New York Telephone Company on June 20, on recent developments of the Laboratories.

G. B. THOMAS AND JOHN MILLS attended on June 22 an educational conference arranged by the Chesapeake and Potomac Telephone Company for engineering and science professors of the colleges in its territory, and described for the conferees the work and organization of the Laboratories.

L. S. O'ROARK addressed the North Carolina Society of Engineers at Asheville on June 21, on "The

Electrical Transmission of Personality."

W. C. TOOLE AND J. A. JOBLIN received degrees on June 7 after post-graduate work at the Brooklyn Law School of St. Lawrence University. The former received the degree of Doctor of Jurisprudence; the latter, that of Master of Laws.

G. F. FOWLER, whose term on the Papers and Meetings Committee of the New York Electrical Society expired last month, has been reappointed for the coming year.

MISS HELEN M. CRAIG attended the annual conference of the Special Libraries Association held recently at Washington. Miss Craig has also served as a member of the Electrical Engineering Committee of the Association in the preparation of its recently compiled Bibliography of Electrical Literature.

INSPECTION ENGINEERING

W. A. BOYD attended a regular survey conference at Hawthorne during the week of May 28. H. F. Kortheuer and T. Mellors attended a similar conference at Kearny on May 7 and 8.

D. A. QUARLES visited Edgerton, Wisconsin, during the early part of June, in connection with inspection methods for automotive equipment.

OUTSIDE PLANT DEVELOPMENT

C. S. GORDON conducted development studies involving small hand tools in Philadelphia on May 10.

O. B. COOK was in Lebanon, Pennsylvania, studying processes in the manufacture of manhole ladders, on May 19.

I. C. SHAFER visited Trenton, New Jersey, on May 21 to obtain data on the results of a year's natural weathering on a trial installation of drop-wire attachments.

E. ST. JOHN visited Boston in connection with development studies of cable rings.

B. A. MERRICK visited Binghamton, New York, and Easton, Pennsylvania during the early part of June for development studies in connection with linemen's tools.

C. H. AMADON visited Silva and Ceredo, West Virginia, and Asheville, North Carolina in connection with timber studies. On June 12 and 13 Mr. Amadon attended the summer meeting of the American Wood Preservers Association in Chattanooga, Tennessee.

RESEARCH

FRANK GRAY, J. W. HORTON AND R. C. MATHES are the recipients of the prize for the best paper on Theory and Research presented before the American Institute of Electrical Engineers during the year 1927. The award was for their joint paper entitled "The Production and Utilization of Television Signals," presented at the Summer Convention of the Institute in Detroit, June 20-24, 1927.

HARVEY FLETCHER contributed to the Proceedings of the Institute of Radio Engineers for May an extensive review of "The Theory of Sound," by Lord Rayleigh, from the viewpoint of its current usefulness. The original edition appeared in 1877 and revision came out in 1894, but both were out of print for a number of years, until the second edition was reprinted in the fall of 1926.

MR. FLETCHER delivered a paper entitled "Three Million Deafened School Children—Their Detection and Treatment (Further Data)" jointly with Dr. E. P. Fowler, be-

fore a meeting of the American Medical Association at Minneapolis on June 13. Mr. Fletcher also spoke at the Lions Club Luncheon on "Research Work on Speech and Hearing." He gave a similar talk at the combined luncheon meeting of the Grafil and Canopus Clubs. On June 18, he gave a demonstration, "Our Ears and How They Deceive Us," at a meeting of the American Federation of Organizations for the Hard of Hearing at St. Louis.

J. E. HARRIS AND E. E. SCHUMACHER attended in Philadelphia a conference on a new machine for wiping joints mechanically.

MR. HARRIS attended a meeting of the Metallurgical Advisory Committee of the Bureau of Standards in Washington, on May 11.

LIEUTENANT COLONEL A. S. ANGWIN AND MR. J. A. GRACIE, members of the British Post Office, are visiting the Laboratories for a few months in connection with radio development.

F. DE FREMERY, A. M. STEVENS, C. E. STRONG AND E. H. ULLRICH, from the International Standard Electric Corporation, are also visiting the Laboratories for several months, to study our methods.

R. M. BURNS visited the Chemistry Department of Harvard University on May 5.

C. L. HIPPENSTEEL spent the week of May 21 at Hawthorne in connection with work on diaphragms.

C. W. BORGMANN, R. M. BURNS, A. C. WALKER, J. A. LEE, A. R. KEMP, J. M. FINCH, AND H. T. REEVE attended a meeting of the A. S. T. M. at Atlantic City the week of June 25.

H. T. REEVE visited the Norton Company at Worcester, Massachusetts, on May 14 and 15 to investigate crucibles for melting precious metals.

K. K. DARROW has taken a leave of absence for a summer abroad and will spend a month in England, France and Germany. While there he will attend various electrical and physical society meetings and visit a number of laboratories.

R. C. MATHES has returned from a month's trip to the west coast in connection with the installation of the power line carrier system on the 220,000 volt transmission line of the Pacific Gas and Electric Company from Pitt River to San Francisco.

W. P. MASON has received the degree of Doctor of Philosophy from Columbia University. The subject of Dr. Mason's thesis was "The Propagation and Characteristics of Sound Tubes in Acoustic Filters."

H. E. IVES lectured on television before a meeting of the Radio Division of the National Electrical Manufacturing Association at Chicago, on June 5.

MR. IVES received the honorary degrees of Doctor of Science from Dartmouth College on June 9, and from Yale University on June 20.

R. E. WATERMAN will visit Denver, Colorado; Butte, Montana; Spokane, Washington and Portland, Oregon, to conduct wood preservation tests in conjunction with the Pacific Telephone and Telegraph Company.

L. H. GERMER spoke on "Optical Experiments with Electrons" before the Physics Seminar of Cornell University on Monday, May 28.

C. J. DAVISSON AND L. H. GERMER were the authors of a paper "Reflection and Refraction of Electrons by a Crystal of Nickel," delivered before the National Academy of Sciences, and sponsored by Dr. Jewett.

E. F. KINGSBURY gave a talk on television before the Men's Club of the Rutherford, New Jersey, Methodist Episcopal Church on May 28.

J. M. FENSTERMACHER has been elected to membership in the Edward H. Hall Chapter No. 25, of the Telephone Pioneers of America.

SYSTEMS DEVELOPMENT

F. B. ANDERSON visited Harrisburg, Pennsylvania, in connection with the tests being made on cable insulation measurements.

J. B. SHIEL, F. VAN VOORHIS, W. G. SCHAER AND H. A. LEWIS visited several installations of No. 11 switchboards arranged to handle the unusually heavy summer toll traffic in the Catskill Mountains.

C. W. GREEN was one of the authors of a paper "Carrier Systems on Long-Distance Telephone Lines" presented before the Summer Convention of the A. I. E. E. at Denver.

C. L. WEIS AND F. H. CHASE made tests on the first long-haul single-channel carrier telephone system, installed between Omaha, Nebraska and Storm Lake, Iowa, during the latter part of May.

R. L. LUNSFORD visited Chicago and Detroit in connection with general power plant problems.

R. B. STEELE visited Hawthorne in connection with tests on high frequency carrier telegraph equipment.

R. E. KING spent two weeks at Minneapolis, assisting in the cutover arrangements of the new Main-Atlantic Step-by-Step Office.

M. A. FROBERG has returned from a trip on which noise conditions in the repeater stations on the new Pittsburgh-St. Louis cable were studied.

* * * *

THE first group of students recently finished their period of training at the Laboratories under the new Electrical Communications Cooperative Course of Massachusetts Institute of Technology. Under this option terms at school are alternated with periods of experience provided in Western Electric Company, New York Telephone Company and Bell Telephone Laboratories during the last three years of the course. Members of this group will have another term in the Laboratories and will be graduated with M.S. degree in 1929.



Students from Massachusetts Institute of Technology who recently completed eighteen weeks' experience in the Laboratories. Seated, left to right: A. J. Carey, T. L. Bowser, J. D. Riley. Standing: J. R. Rae, T. B. Perkins, C. M. Day, C. A. Armstrong

Snap Shots from



Kontis clears the bar in the high jump



Finish of the sixty-yard dash: left to right, the Misses Fenton, De Martini, Harrer and Boman



Moffott and Thompson finishing the eight-eighty



Part of our tug-of-war team in action: Simmons, Haffner and Neilson, with Calmar coaching

the Track Meet

Club Notes

Once again West Street athletes proved their superiority when they won the Bell System Track and Field Meet at Erasmus Field, Saturday, June 16. However, the real credit of winning the meet goes to our girls, who scored fourteen of our thirty-two and one-half points. In the sixty-yard dash Marie Boman carried off first place when she won this race in eight seconds flat with Katherine Fenton, also of the Laboratories, second. In the quarter mile relay the West Street team composed of Misses Boman, Fenton, Kaempffe and Reinbold won the race by Miss Boman's spurt down the home stretch. Lillian Kaempffe finished third in the basketball throw.

First place in the one-mile relay was taken by the Laboratories' team, consisting of Pasanen, Moffot, Quinn and Toole. In the eight-eighty, Moffot came in second; Pasanen landed second in the broad jump; Quinn and Gardner took thirds in the 440-yard and the shot-put, respectively. Kontis split third honors in the high-jump. Inspired by Bill Calmar's able coaching, the Laboratories' strongmen—Neilson, Haffner, Simmons, Healey and Prachnaik—pulled a victory from Long Island Traffic's team in the tug-of-war finals.

Music from the Fifty-Ninth Artillery Band enlivened the afternoon; a note of humor was struck by the free-for-all novelty race in which contestants had to snatch up tobacco, corncob pipes and matches, and cross the finish line with smoking pipes.

D. D. Haggerty, President of the Bell System Athletic League, was Director of Games; other officials from the Laboratories were L. P. Bartheld, D. R. McCormack, F. Canavan, J. A. Waldron, C. T. Boyles, L. Drenkard, G. A. Brodley, K. B. Doherty and Marion Braillard.

TEAM SCORE

Team	Score
Bell Telephone Laboratories	32½
New York Telephone Co., B. & W.	17½
New York Telephone Co., L. I. T.	14
Western Electric Co., Hudson St.	9
New York Telephone Co., W. M.	9
New York Telephone Co., S. M.	9
New York Telephone Co., L. I. P.	8
New York Telephone Co., E. M.	6

Baseball

The baseball activities have progressed fairly well, considering the



The winning relay team: Misses Fenton, Kaempffe, Boman and Reinbold

great number of rainy days since the season started. In the Club Interdepartmental League of four teams, the standing at the end of the first half of the season was as follows:

	Won	*Lost*
Systems Development Department	3	0
Tube Shop	1	2
Plant and Shop	1	2
Ringers	1	2

Baseball activities in the Bell System Athletic League are also progressing and are approaching the end of the league season with only three postponed games due to rain. The mid-season standing of the teams in this league was as follows:

National League

	Won	*Lost*	*Tied*
New York Telephone Co., L.I.P.	4	0	0
New York Telephone Co., L.I.T.	2	0	0
Bell Telephone Laboratories, Inc.	2	1	0
Western Electric Co., Hudson St.	1	2	0
Western Electric Co., G.H.Q.	1	2	0
N. Y. Telephone Co., L.I.C. & E.	0	2	0
Western Electric Co., Installation	0	3	0

American League

	Won	*Lost*	*Tied*
New York Telephone Co., E.M.	2	0	0
New York Telephone Co., C.C.	2	1	0
New York Telephone Co., B. & S.	2	1	1
American Tel. and Tel. Co.	2	2	0
New York Telephone Co., C.M.	1	2	1
New York Telephone Co., S.M.	1	2	1
New York Telephone Co., W.M.	0	2	1

Golf

The weather for our outdoor tournament was fortunately perfect on June 2 and 9, although the rainy season preceding the tournament had deprived many golfers of practice. Twenty-eight men out of the eighty starters qualified for the finals. In the qualifying round W. F. Johnson won the medal for low net score while J. Hillier and J. A. Burwell tied with a low gross score of eighty-six, which necessitated taking the best score of these two men in the finals. Burwell's eighty-eight against Hillier's ninety-three won the medal for low gross on June 2. The men qualifying for the finals are as follows:

CLASS A

Flight No. 1	*Net*	*Flight No. 2*	*Net*
J. Hillier	73	W. F. Johnson	65
J. A. Burwell	70	W. L. Kidde	76
H. W. Wood	74	F. F. Farnsworth	73
O. Cesareo	73	H. L. Downing	72
J. G. Roberts	77	C. T. Lewis	76
G. E. Kellogg	77	E. J. Johnson	75
E. H. Clark	79	E. C. Mueller	73

CLASS B

Flight No. 1	*Net*	*Flight No. 2*	*Net*
W. J. Lacerte	67	J. C. Palmer	77
E. H. Elliott	74	J. R. Kidd	77
O. H. Williford	75	T. P. Ingram	78
P. B. Fairlamb	76	A. G. Dalton	78
J. A. Lee	76	O. H. Danielson	78
R. E. Collis	77	J. Hall	79
W. E. Mougey	77	A. C. Keller	79

In the finals O. Cesareo achieved an eighty-four after consistently brilliant playing, and won the watch offered for low gross score in Class A. R. E. Collis, with a ninety-four, won the watch offered for low gross score in Class B. The other prize winners were as follows:

Class A — Flight 1		
Low Net	J. A. Burwell	72
Second Low Net	G. E. Kellogg	74
Class A — Flight 2		
Low Net	E. J. Johnson	75
Second Low Net	H. L. Downing	73
Class B — Flight 1		
Low Net	E. H. Elliott	75
Second Low Net	W. J. Lacerte	77
Class B — Flight 2		
Low Net	O. H. Danielson	72
Second Low Net	A. C. Keller	73

BELL LABORATORIES RECORD

FREQUENCY MEASUREMENTS
By W. A. Marrison

740-A PRIVATE BRANCH EXCHANGE
By J. G. Ferguson

SUPPRESSION OF HARMONICS
By R. E. Coram

AUGUST 1928 VOL. 6 NO. 6

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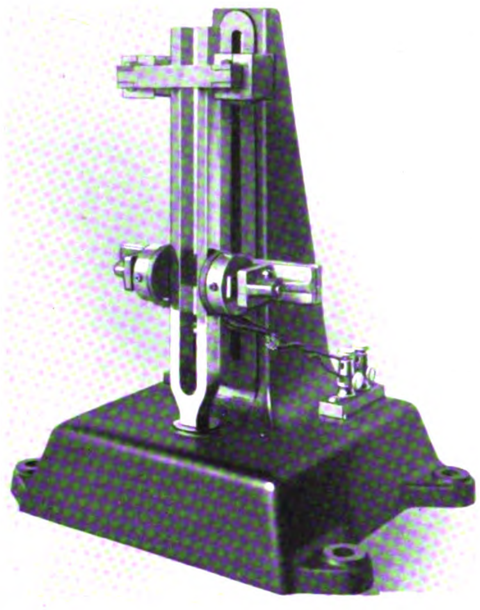
Some Facts about Frequency Measurement

By W. A. MARRISON
Research Department

IN electrical communication we are concerned with frequencies ranging from less than one cycle to 100,000,000 cycles or more per second. In a considerable portion of this range it has become necessary in some cases to measure frequencies with an accuracy approaching one part in a million. It will not be long before it will be necessary to generate currents with frequencies having given values within the same limits, the distinction between the two cases being that in the latter a very precise method of adjustment must be employed in addition to a precise method of measurement. Systems have been developed such as television involving synchronizing at a distance without the use of a control channel, in which it is desirable to maintain frequencies constant to one part in 10,000,000, and it seems now that over reasonable periods this accuracy will be attained with little difficulty. This does not imply that the frequencies would be adjusted to a specified absolute value with this accuracy, but only that two or more independently controlled frequencies would retain their original values within this limit.

It has not been many years since, when one wished to calibrate an oscillator in the audible range, he listened to the tone from a struck tuning fork and compared with it a corresponding tone from the oscillator in question. This method is subject to obvious personal errors largely due to limitations of the ear, in addition to probable errors in calibration and errors due to temperature coefficient, varying amplitude, variable mounting, and abuse of the fork. High frequencies were commonly measured by means of a wave meter, the calibration of which was computed from the circuit constants. This method also is subject to considerable errors, chiefly in determining the values of the circuit constants to use in the formula expressing the frequency. It is not surprising, therefore, that frequency measurements made at different places by different methods and observers failed to agree, in some cases by very considerable amounts.

Since frequency is defined in terms of time, the logical method for mak-



The hundred-cycle tuning fork, showing the driving coils (above) and the pick-up coils (below) from which the vacuum-tube circuits are controlled

ing accurate determinations is to count the number of cycles during an interval long enough to be measured with high precision, while keeping the rate so constant that the mean frequency over the period may be taken as the value at any instant. By employing as the standard of frequency the reciprocal of the accepted standard of time — the period of the earth's rotation on its axis — the measurement is made independent of any artificial "measuring stick" that might be set up. As a matter of fact, it is not possible to give a standard of frequency any physical embodiment, as is done in the case of length and weight standards, because frequency, like velocity or power, is a rate, not a material quantity.

It is comparatively easy to measure one frequency in terms of another, so, rather than make each measurement of frequency in terms of time directly, it is preferable to make all such measurements in terms of a reference standard. Such a standard should be constant and be capable of slight adjustment so that it may be maintained at its nominal value within such narrow limits that the departure is always considerably less than the error in making subsequent comparisons. Obviously any number of such reference standards may be

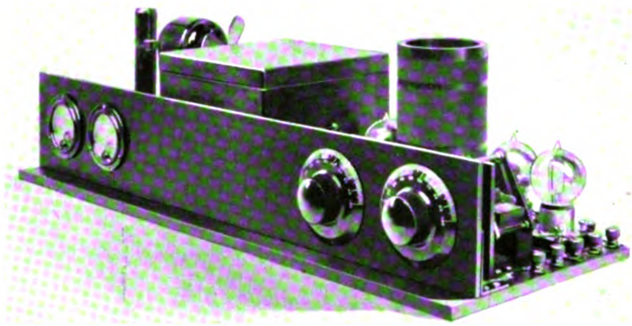


This clock is driven by the hundred-cycle motor which is seen through the window

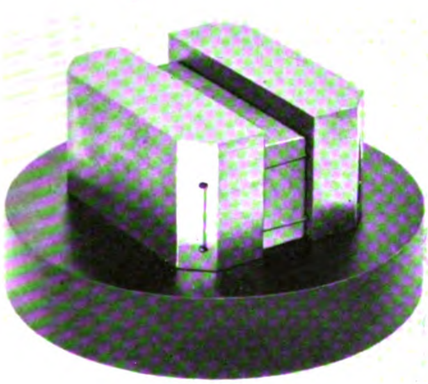
set up without affecting the relative accuracy of subsequent measurements made in terms of them, since the ultimate standard is, in all cases, the rate of the earth's rotation. The frequency of a reference standard should be chosen so as to be most convenient for use in a specified range.

The reference standard, in terms of which most of the precise measure-

ments of frequency in the Bell System have been made since 1923, consists of a 100-cycle regeneratively driven tuning fork. In order to determine the frequency accurately, a synchronous motor is operated by current whose frequency is controlled by the fork. This motor drives a cycle-counting mechanism which, for convenience, is made in the form of a clock. The number of poles on the motor and the ratios in the gear train are chosen so that when the frequency of the fork is 100 cycles exactly the clock keeps accurate time. Any departure in the rate of the clock is, therefore, a measure of the error in the standard. For the purpose of making frequency comparisons with this standard, current at 100 cycles obtained from the vacuum tube circuit is distributed wherever required.



This oscillator is controlled at 50,000 cycles by the quartz crystal



A 50,000-cycle quartz crystal in its mounting

The fork, being made of ordinary tool steel, has a temperature coefficient of one part in 10,000 per degree centigrade and must therefore be controlled to within about 0.01°C. in order to reduce sufficiently the variations in frequency due to temperature. In normal operation the frequency controlled by the fork may be depended upon to within one part in 100,000.

In recent years it has become necessary to measure higher frequencies, and to measure all frequencies with greater precision, than formerly. To meet the new conditions, a new form of reference standard has been developed in the form of an oscillator controlled by a quartz crystal, with auxiliary equipment to facilitate determining and regulating its frequency and for supplying current at frequencies convenient for comparison over an extended range.

The equipment for determining the frequency of the crystal is somewhat similar to that used with the fork standard. It consists of a clock driven by a synchronous motor operated by current controlled at a comparatively low frequency which is an exact submultiple of the frequency of the crys-

tal. The frequency and gear ratios are so chosen that when the high frequency has its normal value the clock keeps accurate time. Any variation in the rate of the clock is, as with the fork-clock, a measure of the error in the standard. So constant is the frequency of the crystal that the clock controlled by it keeps time accurate to one tenth of a second a day.

The frequency of the crystal-controlled oscillator in use at present is 50,000 cycles and the frequency derived from it to operate the motor-driven clock is 1000 cycles. Provision is made for distributing throughout the Laboratories currents at both of these frequencies for use in making frequency comparisons.

The temperature coefficient of the crystal used is considerably smaller than that of an ordinary steel fork, but in order to attain the required accuracy it is necessary to control the temperature to within one or two hundredths of a degree. Atmospheric pressure variations change the frequency in the order of one part in a million, but this can be avoided at any time by mounting the crystal in a sealed container.

To obtain a better idea of the constancy of crystal control, two oscillators having nearly the same frequency were set up so that variations in the low difference-frequency could be determined with high precision. The accuracy of the beat-frequency measurement, when interpreted as the accuracy of the oscillator, is increased many times. By the method used, the relative accuracy, that is, the accuracy of one oscillator regarding the other as constant, could be determined to one part in 500,000,000 during each 5-second interval. Using this method the relative rates were measured over a period of several hours. There were slow variations, amounting to a few parts in a hundred million, having the period of thermostat operation, but over an interval of about four hours the total variation was less than one part in 10,000,000.

As long as the length of a day remains constant within measurable limits, the present method of deriving a working standard of frequency will undoubtedly serve adequately the needs of the Bell System. But the astronomers tell us that at the present rate the length of a day will change about one second during ten years. This is an amount that would soon cause a serious discrepancy between the reference standards and the fundamental standard if the variation continues in the same direction. If the rate of the earth's rotation continues to change, it will be necessary, either to make corrections from time to time in the reference standards, or to adopt a new technique in which something more fundamental than the rate of the earth shall determine the standard of frequency and ultimately, perhaps, the standard of time interval as used in the CGS system.

Continuous Charging for Automatic Branch Exchanges

By LEWIS EARL
Systems Development Department

A VITAL problem in the engineering of private branch exchanges is to provide a power plant of comparative simplicity and low cost where the attendance and supervision required is a minimum and where the floor space taken up by the plant is small. The last requirement assumes considerable importance when it is considered that these private exchanges are frequently installed in office buildings where the annual rent per square foot of floor space is high.

To meet the problem of minimum attendance, two methods of charging are possible. One, used with the larger private branch exchanges, charges the battery automatically when it reaches a predetermined state of discharge. Such a system has already been described in BELL LABORATORIES RECORD.* With an alternative method the charging equipment is connected to the battery continuously and so adjusted that at average load a small trickle charge only flows into the battery. At heavier loads the battery is discharging and at lighter loads it is being charged. As a result the battery never gets extensively discharged and at least once a week become substantially fully charged. This method is particularly suitable for the small private branch exchange, and equipment and circuits have been designed to make two sizes of power plant available: one which will handle up to two and one-half amperes and the other up to five amperes under maximum load conditions in the busy hour.

These small power plants are designed to operate on the local lighting circuits of either direct or alternating current. When the source is direct current a small motor-generator set is used for charging; and when it is alternating current Tungar rectifiers, which have proven so satisfactory for the ordinary radio batteries, are used. The radio type LXL storage battery is employed which also is standard for the larger private branch exchanges where automatic charging is used. Due to their production in large quantities and their wide distribution these batteries are relatively inexpensive and readily obtainable.

These continuous-charging power plants were designed principally for use with the 740-A dial system P.B.X.* which requires a voltage maintained between forty-four and fifty volts. A battery of twenty-three cells was selected as being most suitable for this voltage range. As this battery might reach a voltage approximating fifty-eight volts when fully

* *November*, 1926, *pp*. 87-90.

* *Described on pages* 399-402.

charged at a substantial rate, some form of regulation was necessary in order to meet the fifty-volt upper limit. Two groups of counter-EMF cells, each containing two cells, were used to provide the required voltage

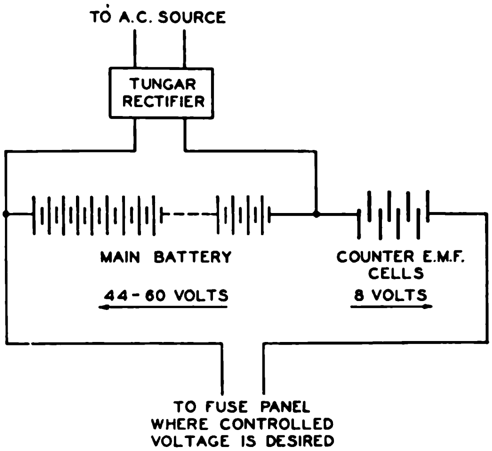
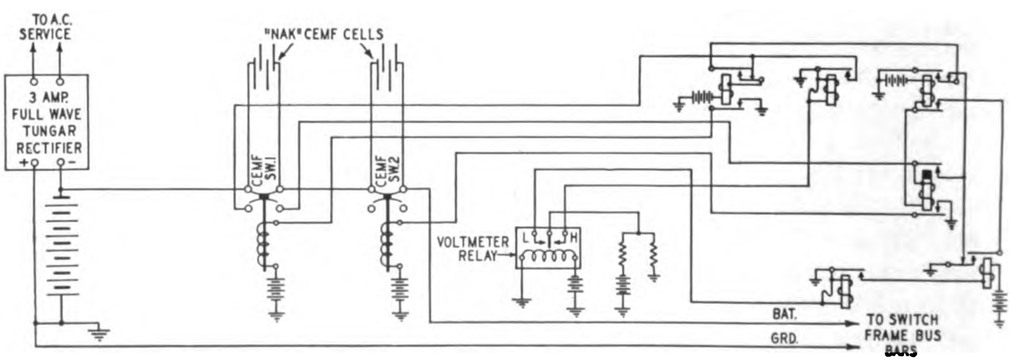


Diagram showing method of connecting counter-E.M.F. cells into circuit to control voltage

control. These counter-E.M.F. cells are connected in the discharge lead from the battery and develop an electromotive force opposing that of the battery itself. The accompanying diagram shows how they are connected into the circuit to cut down the high battery voltage when necessary. Whenever they are not required, they are cut out of the circuit.

Counter-EMF cells are used to a considerable extent in telephone and telegraph power plants for voltage regulation, but the ones previously standard throughout the Bell System are of the lead-acid type. For this P.B.X. power plant, however, a newly-developed cell, known as the NAK, has been used. It has pure nickel electrodes in an alkaline solution. The superiority of the nickel-akaline cells is evidenced by their negligible electrochemical capacity as compared to the lead acid type, and also by their considerably longer life and reduced maintenance. Neither the lead nor nickel counter cells have active material and so neither should store a charge. Actually, however, the lead type is somewhat active electrochemically so that a small charge is stored. The negligible activity of the NAK type makes it possible to short-circuit them in order to cut them out of the circuit, which often simplifies the switching.

The introduction or removal of the counter-EMF cells from the discharge circuit is controlled by a voltmeter relay. When the fuse-panel voltage reaches fifty the voltmeter relay closes its "H" contact; and through a chain of relays the first



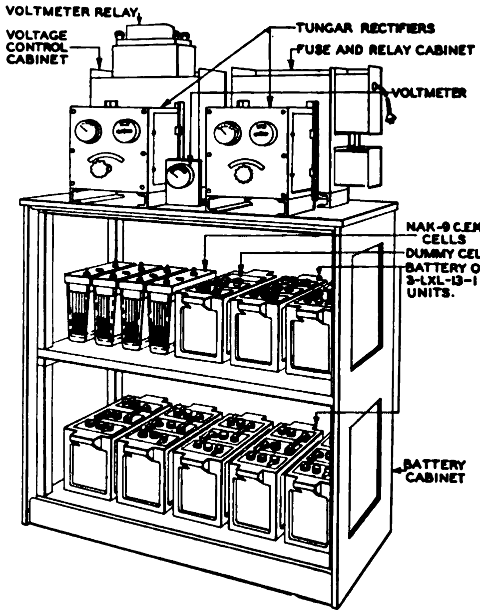
Circuit diagram showing method of cutting counter-E.M.F. cells in and out of circuit

counter-EMF cell switch is operated. This removes the short circuit from the first group of two counter-EMF cells whereupon the fuse-panel voltage drops below fifty and the voltmeter relay breaks the "H" contact. If, due to charging conditions, the voltage again reaches fifty, the voltmeter relay again closes its "H" contact and switch No. 2 is operated. This removes the short-circuit from the second group of cells, causing the voltage again to drop below fifty, after which the voltmeter again breaks its "H" contact.

When, due to increased load, the fuse-panel voltage drops to forty-four, the voltmeter relay closes its "L" contact and through the chain of relays switch No. 2 is operated and places a short circuit across the second group of cells. The voltage now rises above forty-four with the consequent opening of the voltmeter relay "L" contact. If the voltage should again drop to forty-four the voltmeter relay would of course again make on its "L" contact and, through the relay chain, switch No. 1 would be operated and a short circuit be placed across the first group of cells. Following this the voltage would again rise above forty-four and break the voltmeter relay "L" contact.

The chain of relays is so arranged that any part of the above cycle of operation is possible. Switch No. 1, for example, may be operated and then released without operating switch No. 2. If load requirements are such as to require both switches to be operated or released switch No. 2 is always the second one to operate and the first to release. Where the voltage range to be maintained on the switchboard equipment is liberal, such as 20-28 volts, the voltage control equipment described is not required.

An accompanying illustration shows the power plant as it is arranged where alternating current service is furnished. It will be noted that the complete power plant is installed near the switch frame. Its comparative simplicity can be visualized, as it consists of only the charging sets with metal cabinets housing the voltage-



General arrangement of power plant where alternating current is available

control, fuse and relay equipment, separately mounted voltmeter and voltmeter relay, and a cabinet enclosing the twenty-three cell storage battery, the top of the cabinet acting as the foundation for all of the other power equipment. The voltmeter relay, on account of its sensitiveness to stray fields, is separately mounted on a wooden block on top of the voltage-control cabinet.

Acoustic Filters

By W. P. MASON
Research Department

ALL air waves can be considered as made up of vibrations of different frequencies. At the low end of the scale are such steady or slowly varying air currents as the wind, whose frequencies are practically zero, and at the upper end are buzzings of certain insects and other vibrations so rapid that the ear

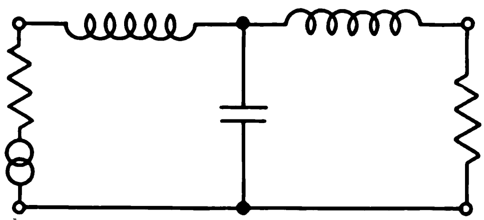
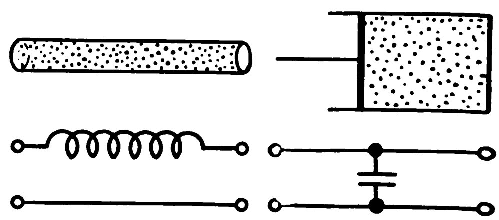


Figure 1

is insensitive to them. It is comparatively insensitive as well at frequencies up to 100 cycles per second, while sounds below about 16 cycles per second cannot be heard at all.

It would often be desirable to separate air waves of various frequencies. For ventilation free movement of the air is necessary, yet some waves of higher frequencies, when they constitute "noise," are most objectionable. Similarly it would often be desirable to reduce the noise components in the exhaust puffs of locomotives. Other instances come readily to mind. Such a separation of waves can be accomplished by an acoustic wave filter.

A wave filter is a device for differentiating between frequencies of wave-motion just as a screen or porous filter separates material of different sizes. Electric wave filters have long been employed in the telephone plant. Figure 1 shows a diagram of one of the simplest types, a low-pass filter with terminating resistances, which passes currents up to a certain critical frequency known as the cut-off frequency and suppresses those above that point. When only the series inductance is interposed between the two terminating resistances, it introduces little change at low frequencies, but as the frequency increases the inductance considerably decreases the current. Similarly the condenser alone has slight effect at low frequencies, but at high frequencies it shunts most of the energy through itself, allowing only a small part to reach the terminating resistance. It might be expected that the combination would allow low fre-



Figures 2 *and* 3—*Acoustic and electrical analogues*

quencies to pass and attenuate the higher frequencies to an increasing degree. Such, however, is not the case; the filter allows a band of frequencies to pass almost without attenuation, and highly attenuates any currents above that band. Other types of electrical filters pass only the high

frequencies, or pass only those in a band between definite limits, highly attenuating all others.

Similarly, filters can be made from acoustic elements, although the mathematical treatment is not as simple as for electric filters.* The air in a short tube, if the rate of vibration is low, can be considered to be moving as a whole, and hence to interpose a mass reaction against any force which tends to move it. A sort of analogy exists between this effect and the electrical inductance of a coil, and also between a closed chamber into which a piston is working and a condenser to which a direct voltage is applied. Combining these simple elements as shown in Figure 4 we have a structure some-

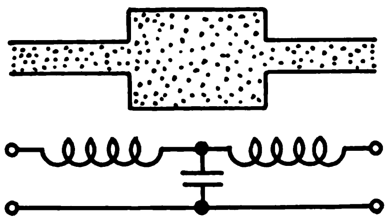


Figure 4—*Acoustic and electrical low-pass filters*

what analogous to a low-pass electrical filter.

These analogues, however, are not close. While it is possible to make electrical elements which are nearly pure inductances, capacities, or resistances, these qualities cannot be so well segregated in acoustic devices, at ordinary voice frequencies. Thus the air in the small pipe does not move as a whole, but is traversed by a wave which takes a finite time to go from one end of the tube to the other. Similarly, the enclosed chamber does not at once oppose the action of a force, as does an ideal condenser, but only after a finite time. For slowly-varying pressures or waves of low frequency, this short time of transmission makes very little difference in the action, but when the time of transmission approaches the time of oscillation of the wave, a marked difference occurs.

A simple acoustic filter is shown in Figure 5, consisting of a main con-

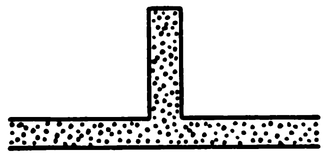


Figure 5—*An acoustic "line" with a side-branch*

ducting tube with a side branch closed on the end. The electrical equivalent of this structure (Figure 6) consists of a line with distributed capacity and inductance shunted at its center by a similar line open-circuited at its end. Some propogation properties of these systems can be deduced by inspection.

Whenever the shunt line is in an anti-resonant condition, that is, when the reflected wave returns in exactly opposing phase with the incident wave, the impedance looking into the shunt is infinite (neglecting dissipation) since the two waves cancel, and a given pressure produces no velocity in the side branch. Under this condition, the side branch will exert no influence on the transmission. The attenuation of the filter will be only that of the main branch, and if there is no dissipation this attenuation will be zero. These anti-resonant points occur when the frequency is such as to make the length of the shunt line 0, 1, 2, etc., half wave lengths and they mark the centers of the pass bands of the filter. Hence, this type of filter passes a low-frequency band,

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* *The possibility of designing acoustic filters whose elements play roles approximately analogous to those of the elements of electric filters was first pointed out by Prof. G. W. Stewart of the University of Iowa.*

a second band whose central frequency is f, a third band whose central frequency is 2f, and so on.

Whenever the reflected waves are in phase with the incident waves the shunt line is in a resonant condition. Its steady-state impedance is then very small, since the series of reflected waves builds up a very large amplitude, and the ratio of volume-velocity to pressure is large. Under these conditions an attenuation band exists, because the shunt line diverts practically all of the motion from the terminating end. Such a condition of resonance exists at frequencies where the length of the branch is one quarter wave length plus any number of half wave lengths; these frequencies, which bear to each other the ratio 1 :3 :5 :7, and so forth, are therefore the centers of attenuation bands.

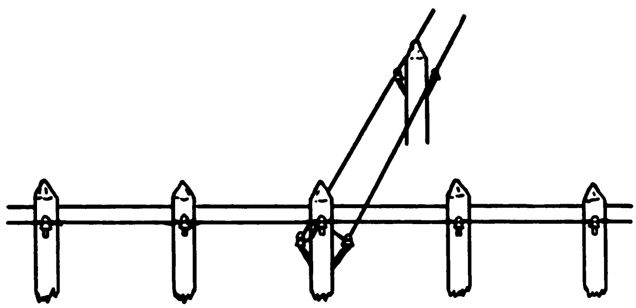


Figure 6—A telephone line with a branch from it analogous to the acoustic system of Figure 5

What part the length of the main tube plays is not so obvious, but analysis* shows that this length determines the relative width of successive pass bands. The most interesting case is where the total length of the main tube equals the length of the side branch, for then all of the transmission bands have the same width. The ratio of the cross-sectional area of the side branch tube to that of the main conducting tube determines the width of the attenuation band relative to that of the pass band. The larger the ratio the greater the width of the attenuation band, for the larger will be the shunting effect.

A more complicated filter is shown in Figure 7. Its main conducting tube, the inside pipe, is generally so small that only the longitudinal vibrations need be taken into account, and with the usual dimensions of the large chamber, radial vibrations need not be considered at the lower frequencies. A longitudinal vibration coming from the pipe travels to the far end of the chamber and is reflected; when it comes back to the chamber wall at the incoming end it is reflected again. When the reflected waves are in phase with the incoming waves, a building up of vibrations occurs until the amount of power passing from the filter into the outlet pipe is equal to that coming in less the amount dissipated in the filter. Since a resonant condition exists at all points for which its length is one-half wave-length, one wave length, or any integral multiple of a half wave length, these frequencies are the centers of successive pass

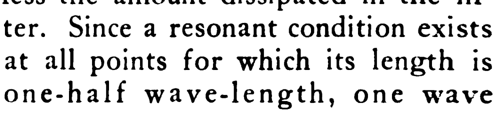


Figure 7—A band-pass acoustic filter

*These relations are discussed more exactly in earlier papers by the present author (Bell System Technical Journal, April 1927, and Physical Review, February, 1928).

bands. On the other hand, when the length of the chamber is 1, 3, 5, etc., quarter wave lengths, the reflected waves oppose the incident waves in phase. Hence the frequencies in this latter series are the centers of attenuation bands. Attenuation bands also exist around the frequencies at which the radius of the chamber is approximately 1, 3, 5 quarter wave lengths, and so forth. There are then two primary sets of attenuation bands with pass bands between; limiting frequencies of all these can be computed from the dimensions of the filter. Maximum attenuation depends on the relative cross-sectional areas of the main tube and the chamber.

Sound vibrations in air were studied long before electric waves on wire were known. A filter like that of Fig. 8 was used by Herschel in 1833. Although acoustic filters are old as compared with their electrical cousins,

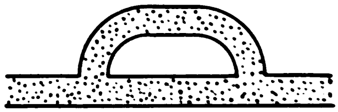


Figure 8

they have not received anything like as much study or development. Acoustic systems are likely to repay further study if for nothing else than for their usefulness in suppressing some of the room noises which are so all-pervasive and which are so annoying to telephone listeners.

A Strange Anomaly

"It is a strange anomaly that men should be careful to insure their houses, their ships, their merchandise, and yet neglect to insure their lives, surely the most important of all to their families, and more subject to loss."—Benjamin Franklin.

If we own a house we insure it for perhaps three-fourths of its value. How many of us have ever stopped to calculate the value of our lives to our families? In terms of affection it is probably beyond price. In terms of earning power, however, it can be easily stated. It is the sum of money which put out at interest would yield a family the necessary yearly income to live according to its present standard. In other words, a man's capitalized earning power, along with his house are among his family's important capital assets. One is of course adequately insured—how about the other?

The payroll deduction plan of life insurance will protect family income and Mr. Lloyd H. Bunting, our insurance expert at the Laboratories, is available to assist in formulating programs and securing insurance.

Apparatus Analysis

By H. L. COYNE
Apparatus Development Department

WHEN apparatus must not only satisfactorily perform its work but give service over a number of years at a minimum cost, its design must involve not only the arrangement of parts to perform a desired end but a detailed study of each element of the apparatus. This study is intended to insure each part's proper working with the whole and to make certain that it will withstand the wear and tear of continual operation with a minimum of maintenance expense and with the lowest consistent first cost. For these studies, the designer invokes the cooperation of appropriate members of the Apparatus Analysis group.

Apparatus analysis requires of those who practice it extensive and detailed knowledge of both mechanical and electrical elements. In the former classification must be considered machine parts such as screws, bolts, rivets, springs, and bearings, and the effect of temperature, moisture, wear, and vibration on successful operation. It is not true, as it appears to the layman, that these parts are simple things about which there is not much to be known. The strength of a machine screw, to take an elementary example, and the force with which it holds two parts together with a given tightening torque, depends not only on its size and the material of which it is made or with which it is plated but on the size, type, and pitch of its threads. A detailed knowledge of the duty cycle to be required of it must be checked against the various types and sizes of screws available if the best overall results are to be obtained.

Not only must a screw be chosen for its strength and the force it exerts, but the likelihood of its loosening in service must be carefully considered. It is held in place by friction which depends not only on the coefficient of friction but on the total force on the threads and clamped surfaces. This must be given the most careful consideration as it changes during the life of the equipment due to many factors such as the external forces exerted during the operating cycle, the loss of resiliency of the screw and of the clamped materials, temperature changes, and vibration which is a particularly fatal enemy of stable assembly.

In general such knowledge is too detailed and analytical for the use of an engineer who is primarily interested in building the apparatus to accomplish some definite and complicated work. His duty is to coordinate parts so that they will carry out his wishes. He works with the apparatus as an operating unit and analyzes the separate parts only far enough to make sure they will accomplish the tasks he assigns to them. His work is with assemblies, the analyst's with details.

Perhaps no mechanical elements of a piece of apparatus require more consideration than springs. The apparatus analyst must make certain that a spring shall exert sufficient force but yet not too much, or unnecessary wear or shock will result to the apparatus. Then, too, the amount of movement the spring must make, the number of times it must operate, and the temperature changes it must undergo are all factors that vitally affect its design both as to form and material. For best results the studies must extend back to the tempering methods used in its manufacture, for tempering is the vivifying element of spring service. So important is this matter of raw materials that special laboratory raw material specifications are now issued to insure satisfactory and uniform products.

Other mechanical design elements of paramount importance are bearings. Type of bearing and method of lubrication both raise an almost endless series of questions to be answered. The speed for which a bearing is designed is always an important factor. This is particularly true of ball bearings which require, for instance, a certain minimum speed of rotation to keep the balls rolling in the center of the race. If they are specified where the speeds are below this value, excess friction between the balls and the containing cages accelerates the wear of the bearing.

Mechanical features of a design, however, are only part of the entire problem. Electrical resistances, inductances, and capacitances and magnetic circuits and materials all come in for attention. In some cases the Apparatus Analysis group serves only in an intermediate capacity in checking these elements by seeing that each has proper consideration from the appropriate specialized group in the laboratory. Other electrical features such as base-metal contact materials and voltage drops due to contact resistance, are passed on directly by the Analysis group. In one way or another, however, they make sure that every detail of the design has had proper consideration and analysis.

A very important part of apparatus analysis is life testing.* Theoretical analysis although essential for good design must be constantly checked against actual operating results. Apparatus and parts must be subjected to all the varieties of stress and strain that they could ever experience in actual service, and so testing with controlled temperature and moisture conditions is an important function of apparatus analysis.

An allied function is the investigation of trouble in the field. Here the testing is actual operating service and a study of the failures is very fruitful of detailed information which may lead to improvement in design as well as to the solution of the trouble.

In addition the Apparatus Analysis group is instrumental in investigating changes proposed by the Manufacturing Department and as a result recommends many modifications to facilitate manufacture and to lead to cost savings that do not otherwise affect the design. Also they specify limiting conditions or tolerances such as hardness of metals, spring forces, contact pressures, or the required tolerances for resistances, voltages, or other electrical constants.

The necessity for extensive testing to insure at all times the best use of materials and parts again emphasizes

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* Bell Laboratories Record, *January*, 1927, *pp.* 155-159.

the desirability of an Analysis group which specializes in laboratory tests. There is a further gain from having each piece of apparatus carefully studied by distinct groups who naturally scan it from somewhat different viewpoints. The system furnishes an independent check on all designs which can not help but be of value.

For the best results it is desirable to have the two groups work together from the beginning of a design. Consultation during the early stages is bound to speed up the final completion and reduce its cost by eliminating the necessity of retracing steps and the possibility of rejected models or samples. Occasionally the completed drawings are submitted for analysis and at other times models are used for the studies. Tool-made samples naturally come to the Analysis group as an established procedure and form the final basis of analysis.

The results of analysis appear in the form of laboratory reports which describe the apparatus and its purpose. In addition they contain results of tests and may suggest new schemes of arrangement conducive to longer life, simpler construction, lower manufacturing costs, and more reliable operation. In concluding, the reports contain recommendations based on results of an impartial investigation made with all the facilities the Laboratories can command. They are for the immediate use of the designer responsible for the apparatus in question and serve as a valuable future reference library for the use of the various design groups.

Carrier Systems in Australia

J. S. Jammer, formerly of these Laboratories and now with the International Telephone and Telegraph Company, tells in that organization's quarterly for July of the adoption of the carrier-current system in Australia. He states that a marked improvement in service resulted after a three-channel carrier system had been installed between Sydney and Melbourne towards the end of 1925. *The success of this first carrier led to the installation of a six-channel, four-wire system between Sydney and Newcastle. A carrier-telegraph system was then installed between Sydney and Melbourne, and between Melbourne and Adelaide. In all, there were installed* 13,000 *channel miles of carrier-telephone and* 6,000 *channel miles of carrier-telegraph circuits.*

Announcing the 740-A P.B.X.

By J. G. FERGUSON
Systems Development Department

RECOGNITION of the value of telephone service to business houses came so soon after the first telephone conversation that a private branch exchange switchboard was in use at Ansonia, Connecticut, less than five years later. Since then the course of development of P.B.X. switchboards has been steady, paralleling closely that of switchboards for central offices. As telephone messages have taken an increasingly important part in the transaction of business, P.B.X. switchboards to meet a wide variety of traffic situations have been brought out, embodying in each case whatever current developments were appropriate. Introduction of the dial in the Bell System paved the way for the 700-C dial P.B.X., which has all its stations connected to step-by-step apparatus for local and outgoing calls. To complete incoming calls, however, an operator is needed, so the stations are also connected to jacks for manual operation. Though this system is feasible for establishments of almost any size, it is ordinarily only in installations serving one hundred stations or more that it is economical to have the lines appear at combined manual and step-by-step equipment.

The majority of business houses require fewer than 100 station lines and to provide these firms with a more satisfactory dial service the 740-A P.B.X. is now available. The cost of operating the new P.B.X. will be considerably less than that for a corresponding 700-C, due partly to the fact that a cheaper method has been devised for handling its incoming calls. These calls come in not to a manual switchboard with a jack for each line but to a small attendant's cabinet containing lamps and keys. The cabinet, which somewhat resembles a cordless P.B.X., will take up only about one square foot of space on a commercial desk. The attendant can therefore do other work when she is not busy with calls and

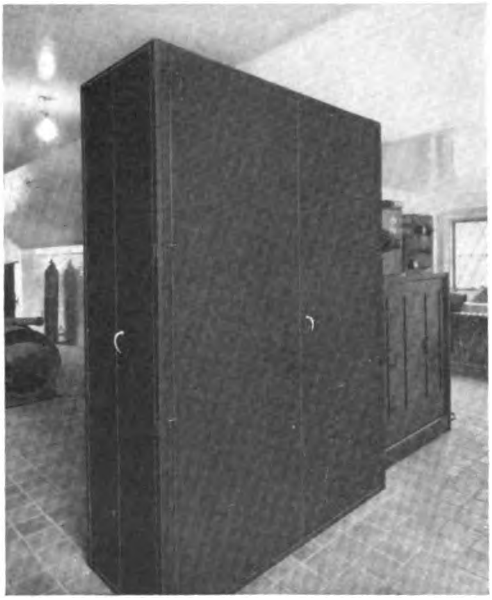


Attendant's cabinet, located in a butler's pantry. The pictures were taken at the first installation, on a large country estate

it is expected that she will be able to give approximately two-thirds of her time to clerical duties.

Keys and lamps on the front panel

of the attendant's cabinet, when used in conjunction with a standard dial sub-set on her desk, enable her to connect a total of ten central office trunks and P.B.X. tie lines to desired extensions; she can also originate local or outgoing calls. Each trunk and tie line is equipped with two keys and three lamps. One key is used to connect the trunk or tie line to the attendant's telephone or to hold it until a required extension is available, the second key connects a station line to a central office trunk for night service and the three lamps show the status of any call in progress. One of two keys associated with the attendant's line must be operated every time she dials, and the other every time she originates or transfers a call. Provision of a second cabinet increases the possible number of trunks and tie lines from ten to nineteen, the maximum that can be accommodated in any installation.



Mechanical and power equipment, in the power house of a large estate. In the foreground, switch frame; to the right, power cabinet

The step-by-step switches and their associated equipment are mounted on the switch frame. One side of this frame provides for the equipment of twenty selector-connectors, nineteen trunk or tie line circuit units and one attendant's telephone circuit unit. The other side is arranged to mount twenty line finders and the miscellaneous equipment associated with the circuits on the frame.

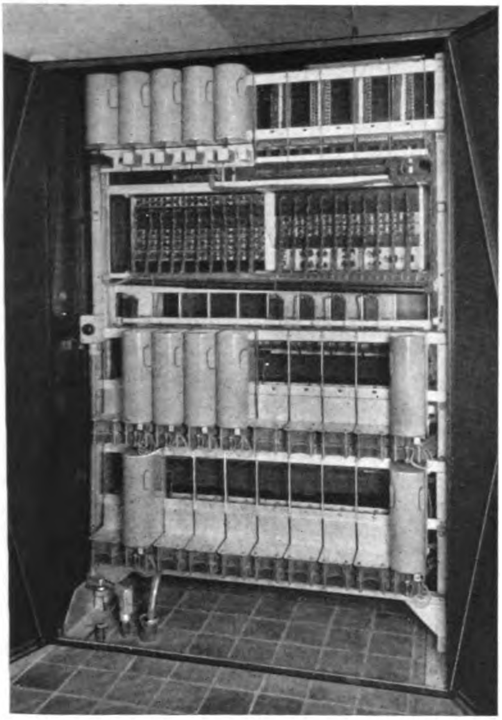
The switch frame is stocked fully wired and equipped except for line and cut-off relays, line finders, selector-connectors and trunk or tie line circuit units which will be provided in accordance with busy hour traffic. When the switch frame is located in an office it will be enclosed in a sheet metal casing finished in olive green.

The power cabinet contains the storage battery with its charging, voltage regulation and alarm equipment.

By operating the dial on the telephone of any station line, it will be possible to connect with any other station line, with the attendant's line, with a central-office trunk (unless the station line is denied central-office service) or with a tie line to an associated distant P.B.X. The dial tie line feature is extremely attractive to a firm which requires efficient communication channels between its branches located in the same city or in adjacent neighborhoods, but too far apart to be served economically by one P.B.X.; the 740-A provides for tie lines to as many as three such distant P.B.X.'s. A tie line permits direct interconnection of two P.B.X.'s without the intervention of the central office operator and the advantage of this arrangement is well appreci-

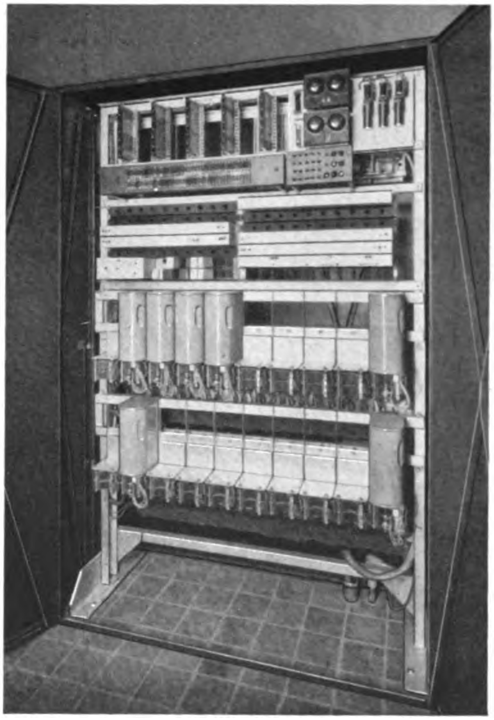
ated by those of us in the Laboratories who have reason to make frequent calls to 195 Broadway.

When any call is being originated, the removal of the receiver from its hook will cause a line finder to operate to connect the calling station to an idle selector-connector. The calling party on hearing dial tone will dial the desired number, consisting of two digits for a station line and one digit for a trunk or tie line, and the selector-connector will operate to connect the calling line to the called station or to select an idle trunk or tie line. Normally the P.B.X. will have a capacity of 88 station lines and 10 trunks to the central office but the station line capacity will be somewhat less than 88 lines where tie lines are provided or where more than 10 central-office trunks are required.



Selector-connector side of the switch frame; at the top, trunk circuit and attendant's circuit equipment

An incoming call will signal the attendant, who will operate a key, find out what extension is wanted, and dial its number. If the line is busy or if the party does not answer, she can dial another extension or hold the call until the desired line is free. When the called party hangs up his receiver, the switches will release without assistance from the attendant, thereby relieving her from interruptions in her other work. On incoming calls the attendant can be summoned by a movement of the receiver hook at the extension and she can transfer the call to another line by releasing the switches and dialing the new number. Night service keys allow each trunk to be connected directly to one station



Line-finder side of the switch frame

line so that night calls from central office can be routed to as many station lines as there are trunks and, since all local and outgoing calls are dialed, a night attendant at the P.B.X. will seldom be required.

From the manufacturing, operating, and cost aspects the equipment of the 740-A P.B.X. is a particularly happy combination. Practically all of its apparatus and circuits resemble corresponding apparatus and circuits in step-by-step central offices so that its manufacturing problems are not new and its maintenance requirements and adjusting procedure are those used in a central office. Its two fundamental units of equipment, the line finder and the selector-connector, are similar in appearance and require similar assembling processes and maintenance routines. Maintenance will be further simplified by the regulating equipment* which will automatically maintain a battery potential between the limits of 44 and 50 volts.

Telephone equipment cannot be manufactured in a day and yet to give efficient service a telephone company should be prepared to supply a P.B.X. to a customer on short notice. Because of the great variations in the telephone requirements of different businesses it is extremely difficult to design a dial P.B.X. which can be speedily distributed and installed. Particular attention was paid to this phase in engineering the 740-A. Like a ready-made suit, it is manufactured in advance to meet the requirements of a percentage of its customers and is easily altered to satisfy the others. Where it fits the traffic requirements without alteration, it is simply necessary to locate the switch frame, the power equipment and the attendant's cabinet and to run their connecting cables; adjustment to traffic needs requires little more than this.

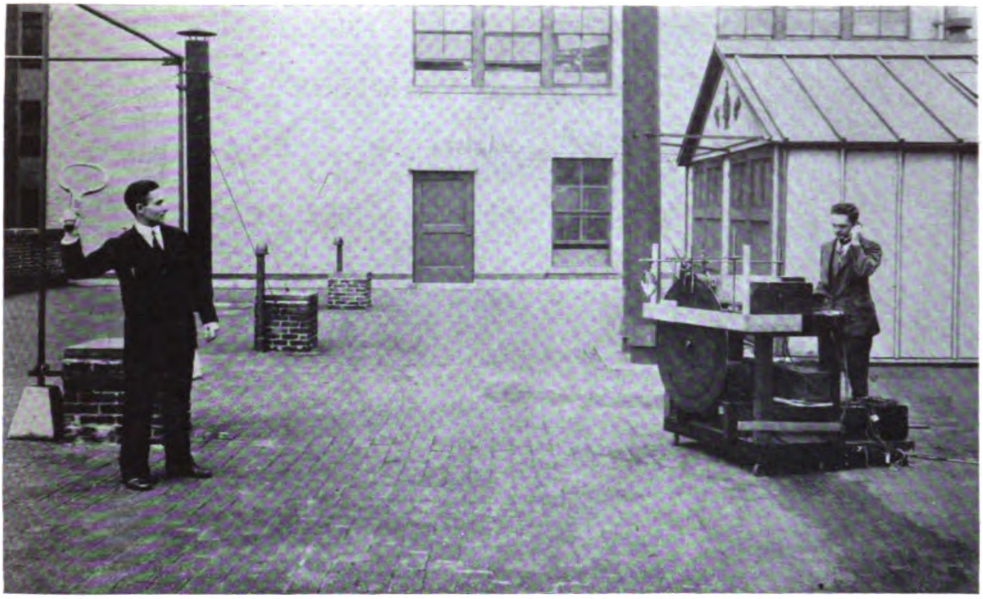
Early orders indicate that the 740-A is a welcome addition to the P.B.X. family.

* *The power plant is described by Lewis Earl on pages* 389-391.

A New Method in Television

JULY 12 saw the first public demonstration of television apparatus using sunlight for illuminating the scene to be transmitted. This marks a definite forward step in the advancement of the art but still leaves a wide gap to be crossed before commercial application of any sort can be contemplated. Two tennis players going through their strokes on the roof of Section G were viewed clearly in the receiving apparatus installed in Room 762. Other actors boxed and danced, swung baseball bats and in other ways provided lively scenes for transmission. The demonstration was given for members of the metropolitan press.

In the first form of apparatus, demonstrated in April of last year, the scene was illuminated by a rapidly oscillating beam from a powerful arc light, and that method limited the scene to be transmitted to a comparatively small area — the area of a person's head and shoulders. The new



Transmitting unit of the new television system. S. D. Morrison swings the tennis racket and J. R. Hefele is at the controls

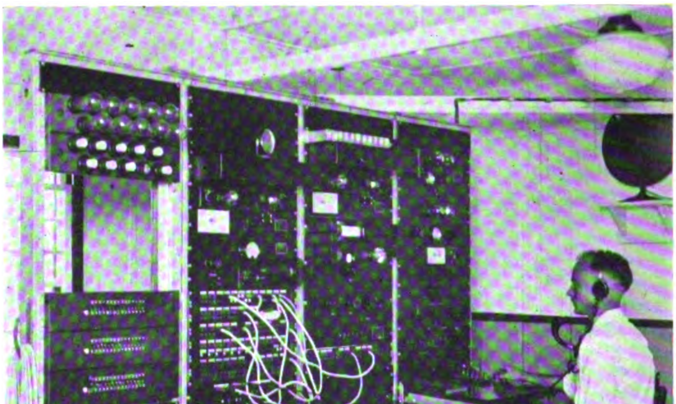
development, by using sunlight as the means of illumination, frees television from one of its most serious limitations.

The scene or event to be transmitted is reduced to the form of an image by a large lens, this image being scanned by a swiftly rotating disc similar to that previously employed but much larger. The light allowed to pass by the holes in the disc falls upon a photo-electric cell of extreme sensitiveness which takes the place of the three large cells formerly employed. The experiments show that moving persons or objects can be scanned when at a considerable distance from the lens, so that the focus does not require changing from moment to moment.

The developments which were demonstrated were perfected by Frank Gray working in collaboration with H. E. Ives. Of principal importance is the light-responsive cell, whose greater sensitivity compared to that of the older cells made possible the other changes. The signals sent out are identical in type with those given by the former transmitting apparatus. No important change has been necessary therefore in the receiving apparatus or in the transmitting medium, whether wire or radio, on account of the improvement which has been made in the transmitter.



A general view of the transmitting station and antenna at Deal



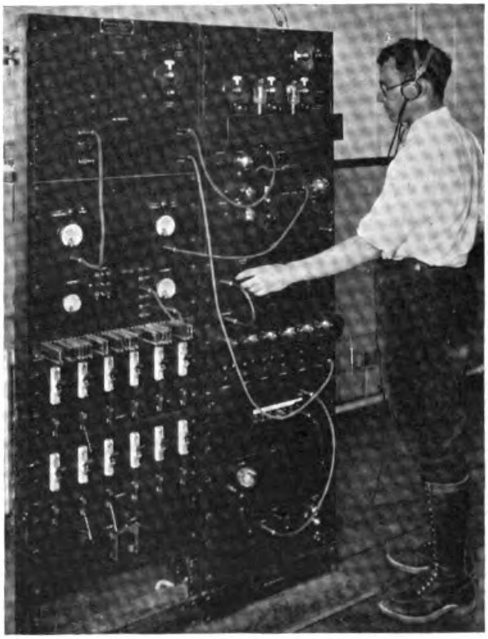
Line terminal equipment at Netcong

The Opening of Transatlantic Service on Short Waves

THE demand for transatlantic telephone service which no longer ago than the first of the year resulted in an average of six to eight calls a day, has recently been producing an average of over thirty with as many as sixty calls on some days. So rapidly has the traffic grown that those of our engineers engaged in designing and erecting the new short-wave equipment to afford an additional channel have found scant opportunity for leisure. Their work is now nearing completion and it is expected that two-way commercial operation will begin shortly.

Short-wave operation so far as our engineers are concerned is not an entirely new thing. It will be recalled that ever since transatlantic service was first opened, we have had a supplementary west-to-east short-wave channel available for use at such times as atmospheric conditions discriminated in favor of short waves as against long waves. Until very recently, however, the British post-office engineers have had no short-wave transmitting facilities for transatlantic telephony and two-way operation upon a short-wave channel is therefore a new undertaking. It is expected that additional short-wave channels will be required in the not distant future to take care of coming growth.

There are several interesting points of difference between the short-wave system and the long. It will be recalled that two-way operation in the case of the long waves has been accomplished on a single wave-length by the use of the single-sideband method of transmission and voice-operated relays which permit of telephone currents traveling in but one direction on the circuit at any instant. Single sideband transmission and working both ways on one wave-length are not now practicable commercially on short waves.



Short-wave radio receiver at Netcong

The voice-operated devices, however, are employed in connection with two slightly different wave-lengths, one of which is used for eastbound speech

and the other for westbound speech.

As a matter of fact, the short-wave telephone channel actually has three pairs of wave-lengths available. Our radio transmission studies over the past few years have shown that each of the wave-lengths is particularly suitable for certain times of day and that with the three of them available, operation is normally possible throughout a large portion of the day. One wave-length is normally best during the daylight hours, a second for night conditions and the third for times when part of the transatlantic path is illuminated and part of it is in darkness. Conditions also vary with the seasons.

While operating on any one wave-length, the short-wave transmitter has its frequency accurately controlled by a vibrating quartz crystal placed in a constant temperature enclosure. The change from one wave-length to another is effected by changing the crystal and also the inductances in the output circuits of the various stages of the high frequency amplifier. The equipment is so designed that a change from one wave-length to another can be accomplished in five to ten minutes.

The American transmitting station is at Deal, New Jersey, and occupies the building and grounds originally used for the ship-to-shore experiments in radio-telephony from 1919 to 1922. Reception from England is at Netcong, New Jersey, where buildings have recently been erected and equipment installed. Both stations are connected by wire lines with the Long Lines building at 24 Walker Street, New York. Here the two one-way circuits converge and become a two-way circuit for connection through the Long Distance switchboard to the lines of the Bell System.

Business and the Telephone

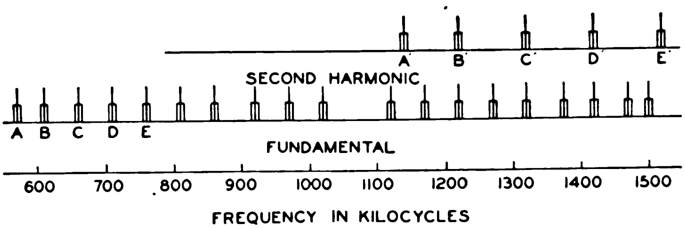
American Telephone and Telegraph reports net earnings of $79,543,000 *in the six months ended June* 30, *compared with* $74,687,000 *in the corresponding period of the preceding year. There is no better barometer of business than the telephone. One might worry if revenues of the telephone companies were on the decline.*

—*Wall Street Journal, July* 18, 1928.

Taking the Harm Out of Harmonics

By R. E. CORAM
Apparatus Development Department

WHEN a radio listener hears two programs instead of one, he is, quite properly, annoyed. And when the unwanted program persists in spite of careful tuning his attitude toward the interfering station is far from cordial. The broadcasting station which operates on an authorized carrier of 600 kilocycles and then for good measure supplements this by sending out its program on 1200 and 1800 kilocycles is offering a kind of good measure of which broadcasting is in no present need. The accompanying chart shows a group of broadcasting frequencies spaced at intervals of 10 kilocycles and also shows the positions occupied on the frequency scale by their second harmonics. With the advent of more and more powerful broadcasting stations, the troublesome interference caused by carrier wave harmonics will increase unless particular care is bestowed upon their suppression.



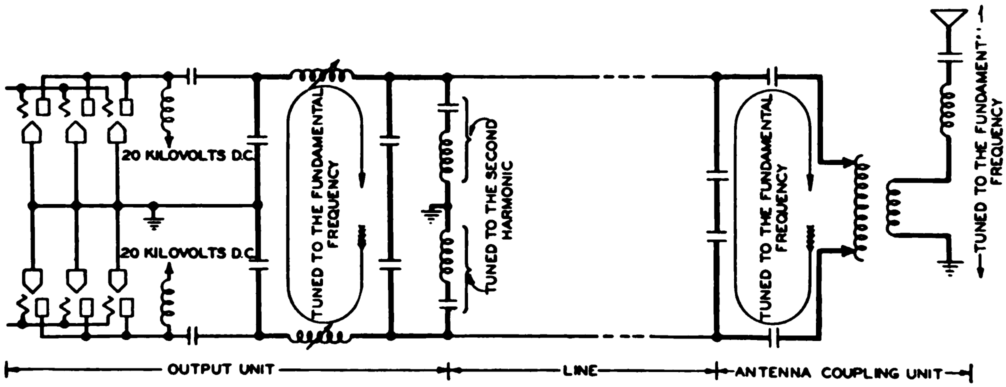
Usually the best way to get out of trouble is to avoid getting into it. In regard to the harmonic waves of broadcasting, this dictum, however, does not apply. It is not practicable to operate a transmitter in such a manner that no harmonics of its carrier wave will be produced. A transmitter free from harmonics would, in a sense, be an electrical analogue of the familiar tuning fork. The tuning fork probably comes as close to producing a pure tone—that is, a tone free from harmonics—as any of the more familiar sounding bodies. Large power output, however, is not one of the requirements of a tuning fork in its usual applications. Accordingly the tuning fork is operated over that part of its input-versus-output curve which is practically a straight line. However, the characteristic of the oscillator of a broadcasting transmitter is sharply bent within its useful operating range. It follows from this fact that any but the feeblest excitation of the radio oscillator generates harmonic waves as well as the fundamental.

Since broadcasting transmitters are necessarily expensive, good engineering economy lies rather in the direction of overloading than of underloading them. This necessarily presupposes the copious generation of harmonics of carrier waves. The designer of broadcasting equipment must, therefore, devise some scheme for by-passing and suppressing these

harmonics whose production he cannot economically prevent.

The problem of freeing the authorized carrier of a broadcasting station of its harmonics bears a certain resemblance to the purification of a chemical compound. Ordinarily, a purity of 80 to 95 per cent can be readily and cheaply attained. To carry this to 99 per cent costs considerably more and to carry it to 99.9 per cent, many times as much. A reduction of harmonic radiation to zero is naturally far from practicable. The extent to which the purification is carried out is now left largely to the designers of the radio transmitter, and they look upon it as an economic balance between the job that they would like to do and the cost of the equipment that can be justified. The more powerful the broadcasting transmitter, the more important becomes the problem of attenuating its harmonics, and the greater the care which must be bestowed upon its harmonic filters.

In this respect, as in many others, 3XN, the latest broadcasting development of our Laboratories, marks a new level of attainment. The transmitter has a power input into the antenna system of 50 kilowatts for the carrier wave alone, and the instantaneous peak power during the broadcasting of a program may reach 200 kilowatts. That is enough power to meet the requirements of a village of over a hundred houses, and yet with all that power in the carrier wave, the amount of the second harmonic allowed to escape would not light the tiniest incandescent lamp made. To be exact, it is less than .005 watt and represents about one-ten-millionth of the power of the carrier wave.



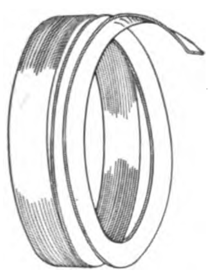
Output circuits of the Fifty-kilowatt Transmitter

The output circuit of the transmitter, with its coils and condensers, constitutes a labyrinth that brings very nearly complete destruction to the harmonics although it lets the carrier pass unhindered. Its operation is similar in principle to that of the electric filter which can separate currents of certain frequencies from currents of other frequencies. The harmonic-suppressing circuits are a sort of filter which wastes away in heat the undesired currents instead of allowing them to escape to spoil DX and short-wave reception.

An Efficient Driving Coil for Loud Speakers

By A. L. THURAS
Research Department

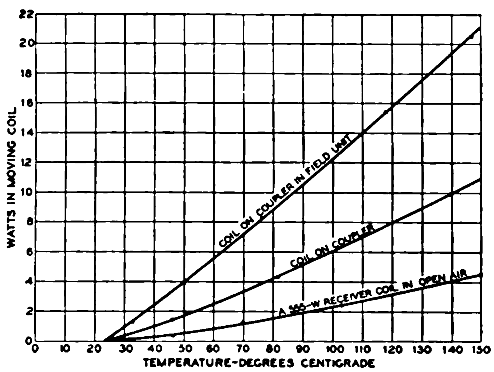
THE high efficiency and quality obtained by the No. 555 loud-speaking receiver,* and the large acoustic power which it is capable of radiating without distortion, are due in considerable measure to a driving coil† of novel form. This coil is a single layer of aluminum ribbon, weighing about one-sixtieth of an ounce. Wound on edge, the wider faces of the turns are adjacent, and are cemented together by the insulation so firmly that the coil can withstand an alternating force of seven pounds. This type of construction serves several purposes. The voltage between adjacent turns is low: hence



Sketch of a driving coil

thin insulation may be used and the effect of distributed capacity is lessened. Wire of rectangular instead of circular cross-section gives a higher space-factor; together with the omission of any supporting framework, this makes possible a smaller air-gap and higher magnetic flux-density.

Heat dissipation is an important factor in loud speakers designed to



Temperature rise of a moving coil of the 555-W receiver

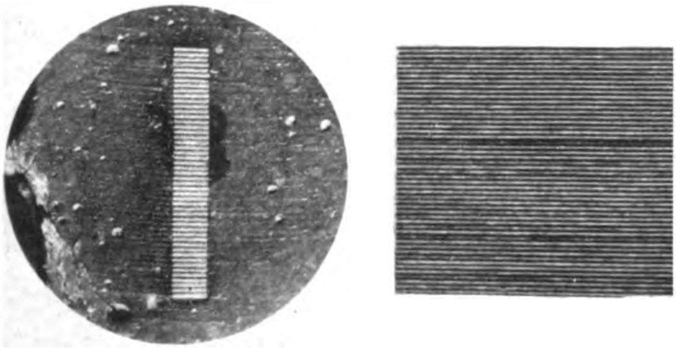
handle large powers. A test was made of a coil first in the open air where it was found capable of dissipating four watts at a temperature of 150 degrees C. Attached to a diaphragm, the coil could dissipate eleven watts, and when finally placed in its operating position in the air-gap it could dissipate twenty-one watts. Radiation across the air-gap is thus seen to play an important part in carrying off the heat; in this connection, a small air-gap has additional importance. The metal of the winding is continuous from the interior to the surface; this contributes to adequate cooling and

* BELL LABORATORIES RECORD, *May*, 1928.
† *For suggestions and development in the design and making of these coils the author is indebted to L. N. Hampton, R. O. Mercner and J. L. Mathison.*

lessens considerably the danger of warping the coil under heavy input.

Lightness of the moving system, due to its simplicity and its use of aluminum, has increased the response at high frequencies and so has improved the characteristic curve. Further improvement follows from the lack of weight in the coil, which otherwise might resonate with the stiffness of various parts of the diaphragm.

First developed for use in scientific instruments to measure acoustic impedances, coils of this type, like many another research device, are now finding application in a number of fields. What was intended to measure the dynamic characteristics of vibrating structures now finds itself launching the exhortations of the politicians or crashing out the drums and brasses of the jazz bands.



A micro-photograph of an actual coil. Left, cross-section of a coil mounted in sealing wax. Right, side view of a straightened section of coil. Both are enlarged about fifteen times. Uniformity of the winding and thickness of the insulation are evident. The curved edges of the ribbon prevent short-circuits which might be caused by rough handling

Dr. H. D. Arnold

At a meeting of the Board of Directors of City Trusts (City of Philadelphia), July 17, 1928, upon the recommendation of its Advisory Committee, there was awarded to H. D. Arnold the John Scott Medal, Certificate and Premium of $1000 for the "development of the three-electrode high-vacuum tube."

THE many friends and business associates of Dr. Arnold are highly gratified to learn that the Directors of City Trusts have awarded to him the John Scott Medal and accompanying premium for the "development of the high-vacuum three-electrode thermionic tube." As a close associate of Dr. Arnold's for seventeen years I should appreciate the privilege of saying a few words to the readers of the RECORD regarding him and concerning his work which has signally contributed to the whole field of communication as well as to related fields.

Dr. Arnold took his undergraduate work at Wesleyan, following this at the same institution by one year of graduate research on electric arcs under Professor W. G. Cady. After receiving his Master's degree in 1907, he went to the University of Chicago on a fellowship and worked under Dr. R. A. Millikan.

In 1910 the American Telephone and Telegraph Company, which had been gradually extending the length of its long distance circuits, had undertaken to solve the problem of transcontinental telephony. To establish such a service economically, it was recognized, a telephone repeater certainly greatly improved over anything then available but more probably operating on an entirely different principle was necessary. Appreciating that the field of electron-discharge phenomena offered very substantial possibilities of affording a solution of the repeater problem, Dr. F. B. Jewett wrote to Professor Millikan, recognized even then as preeminent in this field of physics, and asked him if he could recommend a man to undertake the development of electron-discharge repeaters. It is not, I trust, a breach of confidence to quote from Professor Millikan's letter to Dr. Jewett, saying that he had a man

> who is taking his degree this fall, so that he could go into the employ of the telephone company, if you can make arrangements with him right away. His name is H. D. Arnold; I have had intimate association with him ever since 1907; I regard him as one of the ablest men whose research work I have ever directed and whom I had in classes, and also I know him intimately as a man of the highest character in every particular, and a man who would be satisfactory for the purpose you have in mind; * * *

How well Professor Millikan's choice has been justified the John Scott Medal award is but one evidence.

Arrangements having been completed, Dr. Arnold entered the Engineering Department of the Western Electric Company in January,

1911. After a brief review of certain aspects of the telephone repeater problem, he turned his attention to the development of a suitable repeater element. He first directed his efforts to devices employing a mercury arc and by July, 1912, he had produced a repeater element employing a mercury arc. This repeater was used commercially to a limited extent.

Quite promptly, however, Dr. Arnold's attention was called to the "audion" of Dr. Lee DeForest, one of the most interesting and important inventions in modern electrical art. Although at that time a very crude instrument incapable of being used as a repeater in the telephone plant, Dr. Arnold recognized the possibilities inherent in this instrument and with the full concurrence and support of those responsible for the long toll-line program, he undertook the development which, starting on the basis of De Forest's three-electrode audion, resulted in the production of the modern three-electrode high-vacuum thermionic tube. This tube is adaptable to a wide range of purposes and was specifically adapted by him to commercial use in long distance wire and radio communication.

Speaking more specifically, Dr. Arnold's contributions may be listed as: first, the appreciation of the necessity of a high vacuum, and the development and application of methods for obtaining such a vacuum; second, the recognition of the existence and the importance of the space-charge effect of electrons in such a high-vacuum device, and the calculation of the magnitude of this effect and methods for its adaptation to commercial purposes; third, the development of the theories as to and means for obtaining proper physical constants for the tube in the way of input and output impedances and amplifying ratios; and fourth, the adaptation of tubes involving these newly developed principles to the telephonic problem of long-distance wire telephony and also of radio telephony. He developed designs for these tubes and methods for their manufacture such that they could be reproduced with accuracy and that dependable and interchangeable tubes could be made to meet the telephonic requirements of reliability and ease of maintenance. This work included not only the development of principles as to the spatial relations of the mechanical parts of the tubes but the development, under his immediate direction and at his suggestion, of an oxide-coated filament as a source of electrons within the tube.

The principles which he thus developed have since been further applied and extended but he himself individually was concerned with the first commercial application to wire and radio telephony of the tubes which he had developed. The vacuum tubes for transcontinental line operation met line tests in July, 1914, and public service early in 1915. Other tubes he developed to meet the problems of radio transmission; and these served as generators, modulators, amplifiers and detectors in radio transmission on April 4, 1915, from Montauk, Long Island, to Wilmington, Delaware, and later in the year in transmission from Arlington to Honolulu and Paris, and to other points.

To give any adequate picture of the present-day use of the high-vacuum tube, even in the wire communication plants of the world, would carry me far beyond any space the Editor would permit me. In a word, however, this instrumentality has

made commercially possible the rapidly expanding toll-cable network which today includes the cities of the Atlantic seaboard and the cities of the middle west extending even into the south and southwest. One needs no prophetic insight to see practically the whole of the United States, not to mention adjacent territory, included in a great cable network. In Europe likewise, all of western Europe including the British Isles is being linked together by a comprehensive network of toll cables, made possible by this same instrumentality. Open-wire lines too have been made more effective by the use of the high-vacuum tube either as a voice-frequency repeater or by the use of the carrier method which is itself made commercially feasible by the vacuum tube. The modern loaded high-speed submarine cable also owes its debt to the high-vacuum tube which most readily permits full advantage to be taken of the possibilities inherent in this type of cable.

In concluding, that the reader may not be left with an unbalanced picture of Dr. Arnold's technical contributions, it is but fair to point out that while the development of the high-vacuum tube and its earlier applications were largely the results of his personal work or of work done under his close direction, as the research activities of the Bell System broadened his responsibilities were likewise broadened in scope with corresponding increase in staff for whose work he was responsible. Under his efficient direction, not to mention his very definite contribution of ideas, fundamental research work upon many phases of the communication art has been carried on. These have notably advanced the whole telephone art both wire and radio; they have made available new methods in land wire telegraphy; in submarine cable telegraphy they have furnished a new type of cable with appropriately modified methods of operation; they have given new methods of recording sounds, making possible improved phonograph records and making practical the so-called talking movie; and finally, not to extend the statement further, this work finds more or less direct application to the problem of those with impaired hearing.

E. H. Colpitts

News Notes

DR. JEWETT delivered the Edgar Marburg Lecture on June 27 before the A. S. T. M. Convention at Atlantic City, his subject being "Some Research Problems Involved in Transatlantic Telephony."

THREE NEW MEMBERS from the Laboratories have recently been elected by Edward J. Hall Chapter, Telephone Pioneers of America. They are D. T. May, R. T. Staples and W. V. Thompson, all of the Apparatus Development Department.

FIFTEEN naval officers were entertained in the Laboratories by members of the technical staff concerned with radio engineering, under the direction of O. M. Glunt and E. L. Nelson. These men were afforded an opportunity to visit the Whippany radio station on July 16, and the next day, under the direction of W. Wilson and A. A. Oswald, they visited the radio laboratories at Cliffwood and Deal Beach. All of the officers in the group are this year finishing graduate courses at Annapolis.

P. NORTON attended the June 27 session of the A. S. T. M. Convention at Atlantic City.

APPARATUS DEVELOPMENT

AMONG those in attendance at the Annual A. S. T. M. meeting at Atlantic City during the week of June 25 were W. Fondiller, F. F. Lucas, H. N. VanDeusen, W. J. Shackelton, E. Montchyk, J. R. Townsend, J. M. Wilson, C. H. Greenall and H. A. Anderson.

H. N. VANDEUSEN, R. M. BURNS AND W. A. BOYD, with W. G. Freeman of the Development and Research Department, visited dial offices in Omaha and Chicago during the week of July 9 to inspect equipment from the standpoint of materials.

I. V. WILLIAMS visited the Service Machine Company at Elizabeth on June 26 in connection with the use of malleable iron in ladder brakes for central offices.

L. B. COOKE spent several days in Johnstown, Pennsylvania, making modifications and adjustments in the power line carrier system of the Associated Gas and Electric Company.

H. M. STOLLER visited the Western Electric shop at Philadelphia to test transformers for control motors of talking moving picture apparatus.

J. J. KUHN made a survey of the Atlantic City Convention Hall, particularly in regard to the Public Address System to be installed there.

H. BROADWELL inspected precision interrupters for testing step-by-step switches in Reading, Pennsylvania, on June 14.

O. F. FORSBERG AND H. W. GOFF visited Hawthorne during the week of June 18 in connection with new developments on terminal strips and dials.

J. N. REYNOLDS AND H. F. DOBBIN were in Hawthorne during the week of July 2 for conferences on dial system apparatus.

V. F. BOHMAN visited Albany on July 6 to observe the operation of

step-by-step switches installed there.

CONSIDERABLE THOUGHT is being given at this time to the extended use of die-cast parts for substation apparatus. In this connection A. F. Gilson and H. T. Martin, with E. V. Reigle of Hawthorne, visited the plant of the Precision Die Casting Corporation at Syracuse on June 19. From their experience in making castings as well as in development of dies, officials of this company gave our engineers much valuable information.

A. K. ASTER addressed the Visual Education Department of the National Educational Association at its convention in Minneapolis on July 5, his subject being "Looking Into the Future Through Electrical Eyes."

D. H. NEWMAN made a survey for the installation of a one-kilowatt broadcasting equipment for the Richmond Development Corporation in Roanoke, Virginia, after which he supervised the installation of a 105-B equipment for the *Chicago Daily News* at Elmhurst, Illinois. In Chicago, he made inspections of the stations of the Moody Bible Institute and the Radiophone Broadcasting Corporation, and in Pittsburgh, inspected the Gimbel Brothers' radio station.

H. S. PRICE visited Cincinnati in connection with work preliminary to the installation of the 50-kilowatt broadcasting equipment for the Crosley Radio Corporation. He also inspected the radio station of the Edison Electric Illuminating Company in Boston.

W. L. TIERNEY is supervising the first installation of a crystal-controlled oscillator unit of Western Electric manufacture at KFI, Earle C. Anthony's station in Los Angeles. He will also supervise the installation of a 106-A broadcasting equipment for Nichols and Warinner at Long Beach and a 105-C equipment for the Western Broadcasting Company of Los Angeles.

THE ARTICLE by J. R. Townsend on Strength Tests of Telephone Materials which appeared in the RECORD for December, 1927, was reprinted in the July number of *Instruments.*

RESEARCH

A. R. KEMP attended the Colloid Symposium held at Toronto University during the week of June 11, later visiting the plant of the Northern Electric Company in Montreal. Mr. Kemp visited the Simplex Wire Cable Company at Boston on June 27 and 28 in connection with developments in rubber covered wire.

C. J. DAVISSON has been invited to present a paper at this year's meeting of the British Association for the Advancement of Science on the work which he and L. H. Germer have been doing on the scattering of electrons by crystals. The meeting will be held in Glasgow from September 5 to 12. While abroad Mr. Davisson will visit laboratories in Scotland and England.

HARVEY FLETCHER attended meetings of the American Federation of Organizations for the Hard of Hearing at St. Louis from June 18 to 22, and at a meeting of the Board of Managers was elected President of the Federation, to hold office for two years beginning in June, 1929. While in Minnesota earlier in the month, Dr. Fletcher visited the Mayo Clinic at Rochester as the guest of Dr. Sheard, head of research in physics.

J. B. KELLY attended a meeting of the American Federation of Organizations for the Hard of Hearing held in Cleveland, demonstrating the 4-A

audiometer, and lecturing on the methods of testing the hard of hearing to a group of teachers who are studying speech reading.

H. E. IVES was a guest of George Eastman at the demonstration of colored moving pictures held July 30 at Rochester.

C. F. KELLER visited the Philadelphia Instrument Shop on June 19, in connection with the production of a testing set for operators' instruments.

A. MELHOSE AND A. D. DOWD have returned from the Azores, and A. B. Newell and M. B. Kerr from Emden, Germany, after making tests on the New York-Azores-Emden submarine telegraph cable.

E. G. MAYER returned June 29 from a two months' stay at Hawthorne, where he made studies in the standardization of analytical chemical procedure.

J. A. LEE visited the plant of the Northern Electric Company at Montreal on June 13 and 14. On June 29 Mr. Lee attended a meeting of the American Society for Testing Materials at Atlantic City.

J. F. WENTZ left for Key West, Florida, on July 2 to make measurements on telephone cables.

A. L. JOHNSRUD lectured on television before the summer session of the University of Minnesota at Minneapolis on July 23.

SYSTEMS DEVELOPMENT

J. MESZAR spent several days at the Cleveland Toll Office in connection with tests on No. 3 toll switchboard equipment.

R. C. HERSH AND E. C. BLESSING have made tests on Type B carrier telegraph repeaters at Elmira, New York.

T. A. JONES is in the far west, making studies of static interference on open wire telegraph lines.

R. W. HARPER AND J. V. MORAN spent several days in Washington, D. C., discussing the introduction of the panel system into that city.

J. G. WALSH visited Syracuse in connection with step-by-step equipment.

L. J. BOWNE made tests on P. B. X. equipment in Albany.

R. E. NOBLE AND I. W. BROWN visited repeater stations at Richmond, Virginia, and Henderson, Norlina and Durham, North Carolina.

R. H. MILLER visited Detroit on June 13 in connection with the new toll equipment now in process for that city.

F. T. MEYER attended the cutover of the new dial system offices in Albany on June 23.

J. G. FERGUSON AND H. D. BRUHN visited the first commercial installation of a 740-A P.B.X., on an estate near Detroit, Michigan.

W. F. MALONE is now in Key West, Florida, and Havana, Cuba, in connection with the installation of additional telegraph facilities over the Key West-Havana cable.

C. BORGMANN visited the Stromberg-Carlson factory at Rochester during the latter part of June.

R. P. JUTSON visited Fort Wayne, Sault Ste. Marie and Detroit, in connection with studies of small automatic power plants.

L. A. O'BRIEN leaves for England about August 8 to supervise the installation of two-way type A picture transmission sets at London and Manchester for the *London Daily Express*. Since July 23 he has been testing the sets at the Philadelphia Instrument Shop with F. G. Gardner

and M. A. Byers of Long Lines, who will accompany him on the installation trip. The group, under Mr. O'Brien's direction, will supervise the work of installation, carry out the operating tests, and train the customer's operators. Mr. O'Brien visited England March 21 to May 8 for an engineering survey of the project, and at that time arranged with engineers of the British Post Office for the circuit to be used.

Outside Plant Development

C. D. Hocker, F. F. Farnsworth and D. T. Sharpe conducted cable fireproofing tests at Whippany on July 9.

E. M. Honan was in Boston from June 27 to 29 in connection with the development of wire testing facilities.

C. S. Gordon, C. D. Hocker, E. M. Honan and F. F. Farnsworth attended the A. S. T. M. Convention at Atlantic City during the latter part of June.

C. H. Klein visited Pittsburgh on July 3 to conduct development studies on metal products.

B. A. Merrick made several trips to Phillipsburg, New Jersey, in connection with development studies on linemen's climbers.

Patent

In company with patent attorneys of the Western Electric Company, J. G. Roberts made a visit of inspection to the Hawthorne Works during the week of July 9.

J. G. Roberts visited Montreal, Quebec, and Akron, Ohio, in connection with patent matters. G. M. Campbell visited Philadelphia, and J. F. McEneany visited Washington for the same purpose.

During March, April, May and June, patents were awarded to the following:

W. J. Adams
A. S. Bertels
B. G. Björnson
J. Blanchard
D. G. Blattner
O. E. Buckley (3)
H. A. Burgess
A. A. Clokey
S. T. Curran
A. M. Curtis (2)
H. F. Dodge
G. W. Elmen
J. F. Farrington (2)
J. C. Field
H. Fletcher
J. W. Foley
W. Fondiller
C. B. Fowler (2)
M. E. Fultz
J. C. Gabriel
J. O. Gargan
W. S. Gorton
C. W. Green
A. Haddock
H. C. Harrison
R. V. L. Hartley (2)
W. H. Harvey
R. A. Heising (4)
E. T. Hoch
F. A. Hoyt
H. E. Ives (2)
W. C. Jones
W. C. Jordan
W. A. Knoop
G. A. Locke
M. B. Long
F. K. Low
C. W. Lucek (2)
G. R. Lum
D. MacKenzie
E. C. Manderfeld
R. C. Mathes
E. D. Mead
C. R. Moore
E. R. Morton (5)
W. E. Mougey
E. C. Mueller
P. B. Murphy (2)
E. L. Norton
A. A. Oswald (4)
E. Peterson
W. A. Phelps
A. Raynsford
J. C. Schelleng
E. E. Schumacher (2)
O. A. Shann
H. M. Stoller (5)
D. M. Terry
G. Thompson
G. M. Thurston
H. W. Ulrich
H. Vaderson
W. Whitney
S. B. Williams

Inspection Engineering

During the latter part of June and the early part of July, meetings were held at Pittsburgh, Philadelphia and Washington to inaugurate review conferences in connection with Field Engineering work. Representatives from the Telephone Company Engineering Departments, Western Electric Company Distributing Houses and Installation Department were present. G. D. Edwards, A. G. Dalton, R. J. Nossaman and W. K. St. Clair were the representatives of the Laboratories.

E. G. D. Paterson visited the plant of the Ohio Seamless Tubing Company at Shelby, Ohio, and that of the National Fireproofing Company at Aultman, Ohio, to observe methods of manufacture and quality control of steel tubing and vitrified clay conduit.

R. M. Moody attended a regular survey conference on cable terminals at Hawthorne during the week of June 18. The following week O. S. Markuson attended a similar conference on lead covered cable. R. M. Moody and H. C. Cunningham attended a survey conference at Kearny during the week of July 9 on inspection methods for relays.

T. L. Oliver has been appointed Field Engineer in the territory of the Southern Bell Telephone and Telegraph Company with headquarters at Atlanta, Georgia. R. J. Nossaman visited Atlanta during the week of July 2 to introduce Mr. Oliver in this territory.

J. A. St. Clair, formerly in charge of the Atlanta headquarters, will take charge of the Field Engineering work in the territory of the Pacific Telephone and Telegraph Company, with headquarters in San Francisco.

General Staff

On the afternoon of June 20, S. P. Grace addressed a group of executives and supervisors of the New York Telephone Company in their auditorium on the work and developments of the Laboratories.

Mr. Grace visited the Hawthorne works during the week of July 9.

A. E. Waight, formerly an instrument maker in the Model Shop, died on June 30. He entered the Western Electric Company in 1899, and was retired last year. At the time of his retirement Mr. Waight was entrusted with the adjustment of micrometers and other measuring devices, a field in which his skill and care proved exceedingly valuable.

Club Notes

The Laboratories' team in the Bell System League did not play any of its regular scheduled games in June due to the great number of rainy days. Games were scheduled for June 5, 19 and 29, but have all been postponed on account of wet grounds. At the present time the team representing the Laboratories is in second place and has an excellent chance of winning the National League Championship and having the opportunity to take part in the post-season championship series with the winner in the American League. A Spalding trophy will be given to the winner in each league and the team winning the post-season series will receive prizes valued at one hundred and fifty dollars.



The Laboratories Club Interdepartmental League completed its 1928 season on Monday, July 9. The championship was won by the team representing the Telephone Systems Development Department without the loss of a game. This is the second championship which has been won by this department since the Club was organized and is due to a great extent to the excellent cooperation among the baseball players of Mr. Dixon's organization. The Ringers, a team which was composed of the baseball players from the Research Department, Commercial Department, and Apparatus Development Department, finished in second place. Each man on the winning team will receive as a prize a Parker fountain pen and a similar prize will be given to the most valuable player on each of the other teams in the league.

Music

Although the orchestra and glee club completed their scheduled weekly rehearsals early in May they plan to continue these activities during the summer months under the leadership of members of their own organizations Both groups are always glad to hear from new members and cordially invite musicians and vocalists to attend one or more of their summer rehearsals. Both organizations have completed their plans for the rehearsals which will start in October under the direction of professional leaders.



Tennis

The Bell Laboratories Club will hold its first tennis tournament during September and October of this year. All matches will be doubles and will be played at the Mammoth Courts, New York Avenue, Brooklyn, starting Saturday, September 22. All court fees will be paid by the contestants and prizes will be donated by the Club. If you plan to compete in this



tournament communicate at once with W. Kuhn, Extension 304, or D. D. Haggerty, Extension 542.

Bowling

The Laboratories Club Bowling League held its election of officers and unanimously elected the following for the 1928-29 bowling season:

General Chairman—A. F. Gilson
General Sec. Treas.—T. C. Rice

Chairman, Group A—H. C. Dieffenbach
Sec. Treas., Group A—G. B. Small

Chairman, Group B—L. G. Hoyt
Sec. Treas., Group B—T. V. Curley

Chairman, Group C—G. C. Crawford
Sec. Treas., Group C—K. M. Fetzer

Chairman, Group D—O. H. Danielson
Sec. Treas., Group D—L. H. Bachmann.

Additional information regarding the plans for the coming season will be published at a later date.

Swimming

Tickets for Brighton Beach Baths are sold by the Club for one-half the regular rate charged at the gate and the purchasing of these tickets eliminates any standing in line. The rate to the Laboratories Club members for Saturday is fifty cents and for Sundays and holidays, one dollar. The management of the baths provides handball courts, athletic field, pools for the kiddies, and many other interesting attractions which are all included in the admission fee.